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STRATEGY PAPER

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Culture of Small Fish Species: Opportunities and Challenges

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Abstract

Small fish species are traditionally captured from both lotic and lentic systems and usually considered as 'trash fish'. Apart from their highly nutritive value, some of them are potential ornamental species as well as having medicinally value. Some of them are also found excellent larvicidal fish, capable of controlling mosquito population very efficiently. Unfortunately, these small sized fishes have never been included in aquaculture programme. Most of the small fish species have been shown a declining trend over the years due to various natural and anthropogenic factors; it is high time to rear some of the potential species on a priority basis.

Keywords: Small fish, rearing technique, captive breeding, north-east India

Introduction

North-eastern part of India with vast and varied freshwater habitats is the home to an astonishing variety of fishes and has been recognized as one of the freshwater fish biodiversity hotspot in the world (Kottelat & Whitten, 1996). The region is also known as one of two biodiversity hotspots in India and among the eight states of the north-east, Assam has the largest number of fishes with 200 species (Mahanta *et al*., 2001). Out of the 217 fish species identified so far in Assam, a total of 148 fish species have been assessed to have ornamental value (Bhattacharyya *et al*, 2003). Das & Biswas (2005) and Choudhury & Biswas (2005) also reported 70 species of ornamental fishes from the *beels* of upper Assam, most of which have considerable commercial value in the domestic as well as overseas market. Again, Biswas *et al*. (2007) mentioned 93 species of fishes from this region suitable for aquarium rearing. Further, 204 species belonging to 34 Families and 101 genera from the Subansiri sub-basin; of which flood-plain lakes (FPL) was found as the richest habitat (111 species) among all the habitat types studied (Bakalial *et al*., 2014). However, lack of management and zero investment, fish yield per unit area from wetland ecosystem is moderate and often very erratic (Biswas, 1996).

Why small fish?

*As edible and ornamental***:** Incidentally, most of the fish species recorded from the region are small sized (< 15cm) and almost all of these small fish species are considered as 'food fish'. A large number of these small sized species have been exported to outside the country as 'aquarium' or 'ornamental' fish in the last two decades or so. Ornamental fish is often used as a generic term to describe aquatic animals kept in the aquarium hobby (Livengood & Chapman, 2009). Ornamental fishes form an important commercial component of aquaculture, providing for aesthetic requirements and upkeep of the environment (Swain *et al*., 2008). The growing interest in aquarium fishes has resulted in steady increase in aquarium fish trade globally. European Union is the largest market for ornamental fish. India has the potential to capture 10% of the global ornamental fish market; but currently our contribution is <1% in the export market. The export of ornamental fishes from India is mainly confined to wild-caught species and the north-eastern states are the main contributors (Mahapatra *et al*., 2004).

As biomonitoring and bio- controlling agent: Certain small fish such as *Danio, Rasbora Salmophasia* are excellent indicator of water quality. Similarly, many of these small fishes are potential 'larvicidal' fish as they prefer mosquito larvae as food (Phukon & Biswas, 2013), thereby effective in checking mosquito borne diseases like malaria, dengue etc. Biological control using larvivorous fish was important in malaria control programme in the 20th century, particularly in urban and peri-urban areas for immediate use in developed and developing countries. For mosquito control programmes, many types of fishes have been used across the world (Rao et *al.*, 2015). These species for instance, *Channa, Puntius, Trichogaster* spp. are more effective as larvicidal fish than the exotic species like *Gambusia* and guppy in Indian condition.

Medicinal importance: Some of these small fish have traditionally used against various ailments in rural areas. 17 species of fishes were found to be used as 'medicinal fish' in the Brahmaputra basin (Bania, 2011). Among them, murrels (*Channa spp*), sleeper goby (*Glossogobius giuris*), devil catfish (*Chaca chaca*) and several cobitids are noteworthy. *Channa punctata* and *C. gachua* are traditionally used for treating asthma, *Clarias magur* and *Heteropneustes fossilis* are well known for their therapeutic value. Both these species are used to cure general weakness. Moreover, *H. fossilis* is found to be used against fungal infection as a paste. *Glossogobius giuris* (locally called *Patimutura*) is another variety frequently used for prevention urination in sleep that is fairly common in adolescent age. Similarly, the flesh of *Chaca chaca* is mixed with certain herbs and the paste is used against certain gynaecological problems. *Monopterus cuchia* is widely prescribed for anaemic patients. *Puntius sophore* is believed to cure malaria. A special item called "*hukoti*" is prepared by grinding the dried fish (*P. sophore*) and mixed with *Colocasia* sp and this is believed to have anti malarial property (Bania, 2011). On the other hand, *P. sarana* is said to restore eyesight.

Habitat variability: The following major types of fish habitats have been identified in the region (Boruah & Biswas, 2002): - (a) *Fast flowing streams:* Rapid streams in the highlands, having relatively steep gradient and rocky bed that harbour small stream fish genera like *Nemacheilus, Garra, Barilius,* and *Danio* which hardly grow beyond 15 cm; (b) *Upstream pools:* These are the sluggish and deeper parts of the upland rivers. Species like *Tor putitora, Bangana dero, Labeo pangusia, Neolissocheilus hexagonolepis, a*nd *Raiamas bola* inhabit this type of habitat; (c) *River meandering and confluence:* The eddy, counter-current system at the junction of two rivers (tributary and main river) is an ideal place for fish assemblages. The confluences are also the passageways for upstream fish migration. Hence, the channel meanderings offer suitable habitats for a large number of fish species; (d) *Ephemeral streams*: These steams are 'alive' during rainy months. A variety of small fish including hill stream species are encountered from this habitat; (e) *Seasonal water bodies*: Paddy fields, derelict ponds, road-side nallahs, swampy area are also important 'homes' for small sized fishes; (f) *Open River:* The river in the plains harbours a wide variety of fish species; (g) *Floodplain Lakes* (FPL): FPL's are weed infested shallow water bodies temporarily (closed) or permanently connected (open) with the main river. These act as feeding and breeding grounds for many riverine species but do have a 'residential' fish population of which air-breathing forms like *Channa, Clarias, Anabas*, etc. constitute about 40 % of the wetland fisheries.

Advantages of small fish culture:

- *Available water bodies*: The region is one of the highest precipitated regions in the world. Extensive seasonal water bodies in the form of wetlands, paddy fields, backyard ponds, nallahs etc. are available intensive and semi-intensive rearing.
- *Favourable climatic condition*: Sub-tropical climatic condition favours the growth and production of most of small sized fish species.
- *Huge work force*: There is no dearth of human resource in the region. If properly motivated, unemployed youths, marginal farmers, women-folks will be interested in small fish culture.
- *Traditional practice*: Small fishes are traditionally stocked in seasonal water bodies (paddy fields, road-side *nallahs* etc.) during monsoon. By simulating the habitat, small fishes can be bred in captive condition.
- *Minimal management*: Not much skill is required for culture of small fishes. As the rearing period for small fishes is for a few months and requirement for their culture is limited; management is not a big issue. In fact, management practice is negligible in comparison to carp/ intensive aquaculture.
- *Limited requirement of space*: Space is not a limiting factor small fish culture. A small area, a $10m^2$ or less area is adequate for rearing small fishes. Even roof-top of high rise building in urban areas can be used for small fish culture.
- *Large domestic market*: 95% of the population in N.E. India is fish eaters.

  In fact, the region is still self sufficient as far as fish production is concerned.

Key issues: Major issues involved for the development of small indigenous fish culture are as follows:-

1. Cost effective good quality fish feed for brooders, larvae and juveniles

2. Skill and entrepreneurship development by providing proper training to the local youths

3. Proven breeding techniques and economically viable breeding protocols for highly valued fish have to be transferred from lab to land for mass scale seed production

4. Development of small/ornamental fishery as a small scale industry

5. Key issues are institution related, infrastructure and production related, supply and delivery related and also societal.

Strategies for development: The various steps to be taken for expansion of small fish culture may be summarized as follows:-

(a) *Maintenance of water temperature*: Water temperature of the rearing enclosure plays a crucial role; hence low cost technology for control of temperature is to be developed.

(b) *Establishment of 'brood bank'*: Brood bank for each type of available species to be established locally for ready supply of brooders/ seed.

(c) *Production module for small fish culture*: More participation of locals especially by involving Women SHG's.

(d) *Conscious wild collection of species to avoid stock depletion for sustainability*: Judicious collection of target species from the natural habitat. Unsustainable exploitation will deplete the natural stock. There are species specific collection methods which will minimize the collateral loss through mortality of non-targeted species.

(e) *Acclimatization*: Adaptation of collected fish in the new environment (separate enclosures) for a varying period of time.

(f) *Monitoring of water quality*: Regular monitoring of physiochemical parameters of the tank as well as health of fish.

(g) *Coordinated approach of concerned agencies*: Coordination of all stakeholders including the concerned Government Department is necessary for successful implantation of the programme.

As on today, more than 300 fish species were described from the region and approx. 80% of them may be categorized as small fishes (<15cm). Some small food/ ornamental fishes of the region are – *Amblypharyngodon mola*, *Badis assamensis, Botia dario, Chaca chaca, Channa bleheri, C. gachua, C. stewartii, Danio devario, Esomus danricus, Glossogobius giuris, Mystus dibrugarensis, M. vittatus, Puntius/Pethia* spp, *Trichogaster fasciata, T. lalia, Macrognathus aral*, *Nandus nandus* etc. None of the above are reared commercially. Some of small varieties fish particularly the 'lentic species' can be bred without much technical knowhow. In fact, few of the wetland species are successfully bred in confined environment. A schematic diagram for breeding of wetland species is given below:-

Conclusion:

Many of our fish species, some of them are either endemic or having restricted area distribution, have been declining very sharply due to various natural and anthropogenic factors (Biswas & Boruah, 2000 a,b). A combination of factors like overexploitation, pesticide and aquatic pollution, spread of disease, uncontrolled introduction of exotic fishes, and habitat modification due to industrialization and urbanization are responsible for depletion of natural stock. Clandestine trade of organisms and indiscriminate collection of wild stock are major causes of concern.

It is often advocated for inclusion of more indigenous species in aquaculture programme for increase fish production. Another major issue is the standardization of breeding protocol suitable to the climatic condition of the region. But the major impediment in artificial propagation of indigenous larvicidal/ ornamental fish is the limited knowledge of their biology. Knowledge of the habitat and biology, especially feeding and reproductive biology of the species concerned is vital for successful rearing of any wild species. Furthermore, adequate amount of quality seed of the target species is also a prerequisite and to achieve this, standardization of breeding technique for mass production of spawn in controlled condition have to be developed before taking up any new venture. Emphasis need to be given to utilize seasonal water bodies like wetlands, swampy areas,

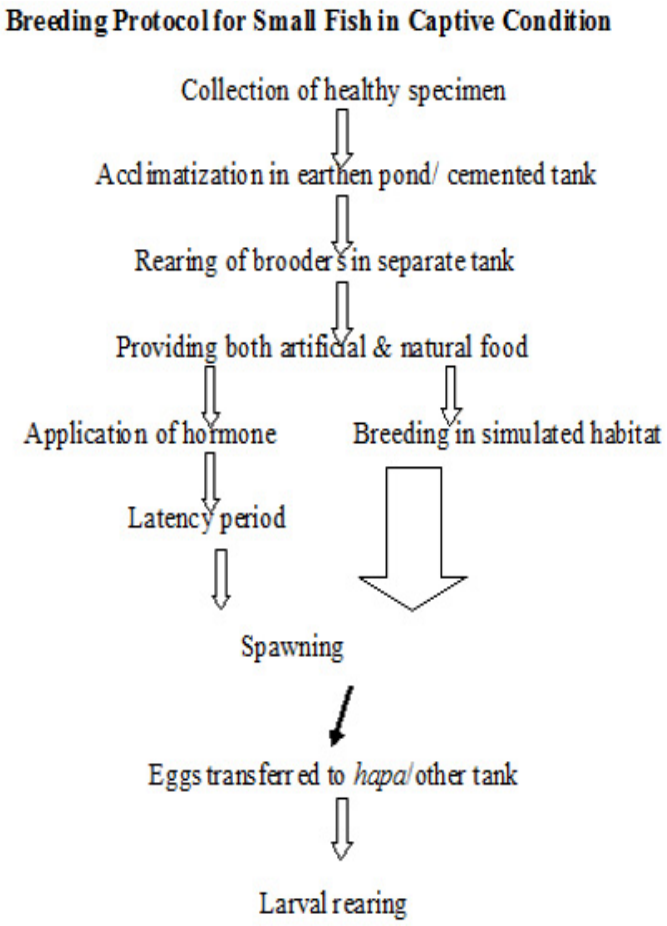

Figure 1: Breeding protocol for small Fish in Captive Condition

paddy fields and *nallahs* for mass rearing of ornamental fishes. Practically seasonal water bodies act as nursery ground for all the wild fish species.

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A trans-disciplinary approach in science for mutually constructive interplay of science and technology

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Abstract

Science if it has to be the systematic knowledge of the natural phenomena, the cause and purpose of how the events occur in nature, then Technology could be the way how these natural events can be tapped to benefit living beings, and how these can be altered, can be regulated, and controlled for making it conducive for sustainable living. Thus technology should provide amenities and facilitate living.

At a stage when all the amenities are available and people experience facile living conditions, would that be a turning point when there is no need for scientific activity to observe, monitor and learn about the natural phenomena? The technology is good enough to provide for conducive living and hence there is no necessity for scientific study?

It is at this question when people consider the availability of resources for technological production. And, inevitably natural resources are limited. Hence arises the necessity for non- conventional resources to supplement naturally available resources. And, this perpetuates the scientific exploration to enable technology delivering goods for the benefit of living beings and technology requiring more inputs of scientific knowledge.

It is in the context of above perpetual need for Science and Technology Education and Expertise, the means is found through systematically imparting knowledge – the educational process. Such an endeavour envisaged in terms of curricular evolution, science is categorized in terms of the variety of constituent disciplines. At advanced educational levels, such a system seeks to enable specialization in the subject matter of any of the disciplines to lead to generate technological expertise. At the formative years children get exposure to General Science and Arts as categories. Then curriculum (1) evolves to provide for natural sciences (botany, zoology, geology, and anthropology), physical sciences (Physics, Chemistry and Mathematics) and social sciences (history, civics). Under arts it is painting, music, dance etc.

With all these achieved it becomes necessary to know in the present days of advanced science and technology, the necessity to recognize interdisciplinary and multi disciplinary approaches (2). Science and technology for performing arts has to be reckoned with.

The under-current of all these is that an individual is able to learn what he is naturally inclined towards, the efficiency seems to be highest. For this the necessary experts to consult on any particular aspect must come from people who have specialized in a subject, and this specialization enables easy reach out by search when in need. Thus at the stage of becoming a human resource (3) an uncanny ability to be all the time be conversant with trans-disciplinary approach to switch between science and technology consistently is the talent to nurture (4).

Key words: Disciplines, Natural Science, Physical Science, Life Science, Transdiciplinary

Introduction

In view of the contents of the enlisted references (*this author's internet publications*) it is the purpose of this contribution to delineate as much as possible by definitions that can appeal to common public what could be a Discipline in the context of Scientific Study, and how can a nature of inter disciplinary and multi disciplinary studies can be envisaged. Then at the frontiers the study could evolve as a transdisciplinary effort. While for the future of Science and Technology (**S & T**) care must be taken that the public is better aware of the consequences of S & T as the betterment of the living conditions, so that maintaining the standard of living occurs as a natural consequence and not requiring extraneous efforts causing stress and strain in the day to day matters related to the life style.

Science education

In this context a pertinent question that surfaces is whether Science Education means essentially Teaching Science subjects or can there be a Science Education, more pervasively than the intent Science Teaching in the class-rooms? A science teaching is an exercise and the practice of routinely conveying what is already known (and hence conventional) as a particular Subject of Study. Thus the terms that are defined m the corresponding class rooms may be even those terms that appeal as a common word in the sense of a day to day communication, as a matter of colloquial language. But to distinguish the significance, is the Educational aspect. A strict Science subject would be indicated by the reference that the word is to be reckoned as a technical jargon, but not to be taken in the lighter vein as if a common utterance. This part can be a contribution by anyone who is knowledgeable and need not be professionally linked with that science subject. Thus is the word **"awareness"** becomes significance to signify that the person who does not know a subject matter, might well know what comprises such a study peripherally and pervasively, and not in any special context meant for teachers and students. Science Education is to know the pros and cons of being scientifically qualified in a subject. This awareness of the distinction of being Knowledgeable pervasively, even if it only be peripherally is a matter of being civilized in the social context than Knowledgeable by going through a qualifying study of the subject matter to specialize.

When this aspect has to be inculcated by the very process of seeking admission to such courses, the word **Discipline** is appropriate, so that it ensures a person is responsible for uttering and doing the necessary study assigned for qualified persons, who get employed. Mixing up the matter in the cloak of being educators becomes a vulnerable act coming under the purview of disciplinary action. In certain contexts even among experts, the use of technically defined terms out of context may be permissible to give accent to the effective science-teaching in the class rooms by compare & contrast approaches. This becomes the part of teaching methods - a pedagogic aspect, to have a built-in consequence of good experience in teaching. **Such cases are exceptional qualifications than to be merely criticized as violations-once again awareness of the teaching responsibilities is evidenced.**

Particularly, when it takes strenuous efforts to prove a possibility and a truth, the teaching methods permit assuming the "false" as "true', and proceed with the proof to soon find it leads to trivially known as an impossibility and hence the assumption was wrong. Unqualified assumptions can lead to catastrophic consequences and outcomes.

Disciplines in science study

In the formative stage learning levels, the science is simply inculcated as an observation of what is happening, monitoring the consequences of the event so occurred, and the specific outcome. Assess the conduciveness to living, and bring in necessary changes as corrections to appropriately alter the course of events for making living a sustainable phenomenon, than becoming a counter-productive occurrence. Thus initial learning is of an awareness level approach of what is known to many of the seniors beyond the mere awareness of it, but the specific reasons and controlling and regulating factors. Thus at the advanced stages of life, a continuous sense of awareness concomitant with the intense specialization is what results in socially a civilization. Classified knowledge of specialization, with a civilized outlook not constrained by the habit of using a jargon. Continuous Education gets the importance.

Thus from the formative level general science awareness, it becomes necessary to stream line the growth and development by expressing the necessity to be more than a mere observer. A controlled observation would be least affecting the phenomenon that is be-

ing monitored and observed. When it becomes necessary that the knowledge acquired by observation to culminate into actions to alter the course of such events, then it warrants that unforeseen results damage the unusual course that was less harmful than the disturbance by the **"Knowledgeable act".** Thus **is** the **distinction of knowledge and Wisdom. Wisdom is the set of inferences based on specialized knowledge.** Merely reporting the observed facts does not always ensure that the necessary wisdom is associated. Thus it is a matter of memory and that of the life experiences with the capability to draw inferences.

While emphasizing on specialization it is important to get the concomitant necessary occurrences distract from the main stream of specializing. Hence a discipline of study warrants a single minded effort at learning of even the unwanted consequences of the knowledge of the subject matter. Requires a maturity in attitudes ensured. Thus is the curricular efforts in the subject of study and the responsibility in transfer of information. Thus aptly the study of the subject is termed the Discipline of study. Every aspect of the field of science has its distinct responsibility and each of this subject matter has a name as a particular discipline of study. While under the category of "SCIENCE" classifications of the following types evolved; Natural Science meaning the current day Physical sciences and Life sciences, Social Science for History, Geography, Economics and Civics, and Humanities Political Sciences, Philosophy and related subject matters. An individual depending on what the preference is opts for a subject listed under Disciplines.

Interdisciplinary study

From the formative year General Science approach to a Classification of Science subjects and under each Class of Science, requirement to study a well defined course results in the Specialization aspect and the Discipline of study in that context. When the specialization in a discipline at the advanced stage requires inputs from the basics of other disciplines, the purview of Interdisciplinary nature of study gets formed. It is important that an individual is well aware of the discipline in which that individual specializes; an expert's purview is on how effectively the specialization can be pursued with the broader outlook on the mutual benefit with other disciplines before it becomes useful to the public at large. In the current days of advanced studies, regimented adherence to specialization in a discipline only limits the benefits of science reaching the public at large. At the same time purposeless transgression into other fields only for the sake of fancy will be resulting in wasteful dissipation and distractions. Hence judiciously reaping the advances from other disciplines and reaching out benefits of specialization to other disciplines is the way of wisely pursuing research. Thus interdisciplinary nature is an natural consequence of awareness of what science is all about while specializing in a particular disciplinary subject. Thus specialization reaches heights with the secure broad base.

Multidisciplinary study

While interdisciplinary nature develops as a natural consequence of specialization in a discipline, it is possible to envisage a study which even from the outset a fall out of the needs from several disciplines. Thus from the beginning it is necessary to provide inputs from several disciplines at the same time and such coordination can be identified as a multidisciplinary task. Thus it may be construed that when experts in the various discipline come together and realize a particular task is beneficial form the context of all the specialists, then a multi disciplinary approach evolves. And it is necessary to realize the need from several disciplines even from the initial stages, it becomes a multidisciplinary activity. Hence if one knows well what a specialization, and expertise is with respect to a discipline, the relevance of interdisciplinary approach and the multi disciplinary start ups is grasped in the right spirit and as much useful as the intent specialization in a discipline.

Science and technology

While Science is concerned with understanding the phenomena that occur, when it becomes necessary to alter the course of events and also regulate and control them from the point of making the phenomena conducive for living for the sake of sustenance of life, the it gives rise to the technology. Thus in general when the utilization of scientific outcomes is intended the technological perspectives become relevant. Thus at the technological level, seemingly less importance on basic research becomes discernible. But that is only a superficial impression and technology requires a principled adherence to basics so that the technological outcomes remain well founded. When such a seemingly basic sci-

ence aspect is not the emphasis, it apparently is the setting in of **TRANS- DISCIPLINARY** attitudes. While evolving a technique much less emphasis on which discipline of study it is. It does not mean the discipline is out of context, but the results from several disciplines are important at the same to enable the necessary regulation and control. When there is an information explosion with stored databases of the outcomes of the various disciplines, to wield the retrieval system to enable faster technological development to bring the science to effectively serve humanity can be possible with the transdisciplinary attitudes. And, to reconcile with such trends is the Trans disciplinary approach which can bring in speedy realization of improvement in the standards of living.

It is possible to elucidate these assertions (5) with the actual research and developments, which probably can be at a subsequent venue.

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RESEARCH PAPER

Pressure dependent study of electronic and magnetic properties of Mn_2ZnSi full Heusler alloy

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Abstract

Full-Heusler alloy Mn_2ZnSi with Hg_2TiCu type structure is found to be a half-metallic ferrimagnet by first-principlescalculations using plane wave pseudo potential method at different pressures. The spin-polarized electronic band structure and density of states at different pressures shows 100% spin polarization around the Fermi energy level with spin-up bandsshowing a metallic character whereas the spin-down bands showing a direct semiconducting band gap across the Fermi energy level. The Mn magnetic moments coupled anti-parallel to each other with different strengths and vary linearly with pressures.Thusshowing ferrimagnetic behaviour with total magnetic moment per unit cell of 2.00 $\mu_B$almostfor the entire range of pressure in accordance with the Slater-Pauling rule.

Keywords: **Heusler alloys, density functional theory, plane-wave pseudopotential, GGA, Half-metals.**

Introduction

The Heusler alloys start gaining interest when de Groot. *et. al*. predicted for the first time that NiMnSb and PtMnB exhibit half-metallic ferromagnetism[1]. Half-metals are class of materials for which one of the spins shows metal like continuous energy bands, whereas for the other spin, the energy bands has a semiconducting gap at the Fermi energy level (E_F). As a result, the electrons at the E_F are 100% spin-polarized. These half-metallic ferromagnets(HMFs) with the advent of time are finding more and more central importance in spin-dependent applications: spintronics[2,3] such as non-volatile magnetic random access memories(MRAM), magnetic sensors[4,5], spintronics giant magneto-resistance spin valve[6] and spin injection to semiconductors[7-9]. HMF properties are observed in many other systems like oxides e.g. CrO_2 and Fe_3O_4[10], the manganites e.g. $La_{0.7}Sr_{0.3}MnO_3$[10], the double perovskites e.g. Sr_2FeReO_6[11], the pyrites e.g. CoS_2[12] and many more. But HMF Heusler alloys are getting more preference than the other HMF systems in spintronics because of their matching lattice constants with other widely used semiconductors. One more criterion which governs the applicability of HMFs is high Curie temperature (T_C) and some of the full Heusler alloys have shown comparatively high T_C. The highest T_C reported so far is 1100K for Co_2FeSi Heusler alloy[13,14] and among the Mn-based full Heusler alloys, the highest reported T_C is 985K for Co_2MnSi[15]. Other Mn-based Heusler alloys also start receiving attention when ferrimagnetic Heusler alloys where proposed as free-magnetic layers for spin-valve structures, low magnetic moments for electrodes and memory[16]. Mn_2CoAl is the first spin-gapless semiconductor (SGS) among the Heusler alloys[17]. Other Mn-based HMFs have already been reported using first-principal calculations for e.g Mn_2VZ(Z=Al, Ga, Sn, Si, Ge and In)[18-20], Mn_2ZnCa[21], Mn_2CuZ(Z=Si, Mg, Al, Ge)[22-25]. Here, we have studied the electronic and magnetic properties of Mn_2ZnSi inverse Heusler alloy as a function of pressure using the plane wave pseudopotential method.

Computational Method

In general, X_2YZ type full Heusler alloys crystallizes in two types of structure: Cu_2MnAl and Hg_2TiCu type structures. When the valence of X is larger than that of Y, the structure is of Cu_2MnAl [26,27] type with the atomic sequence of X-Y-X-Z and the Hg_2TiCu[26,27] type structure when the valence of Y is larger than that of X, with the atomic sequence of X-X-Y-Z. The Hg_2TiCu type structure is also known as XA structure and the Heusler alloys with this type of structure are also called as inverse Heusler alloys. Mn_2ZnSi is an inverse Heusler alloy with Mn at (0 0 0) and (0.25 0.25 0.25), Zn at (0.5 0.5 0.5) and Si at (0.75 0.75 0.75) sites [26,28-30] in Wyckoff coordinates. We treated the Mn at (0 0 0) and at (0.25 0.25 0.25) as different atoms and name them as MnI and MnII respectively.

We performed all the calculations using the Quantum ESPRESSO package[31] which is based on Density Functional Theory (DFT)[32,33], plane waves and pseudopotentials. The exchange-correlation functional is approximated by the Perdew-Burke-Ernzerhof (PBE)[34] scheme of spin-polarized generalized gradient approximation (GGA). The electron-ion interactions were described by Vanderbilt ultrasoft potentials[35]. The Kohn-Sham orbitals were described using plane-wave basis sets and had been expanded up to a kinetic

energy cut-off value of 50 Ryd. The charge-density cut-off was kept at 500 Ryd. For the integration over the Brillouin-zone, an automatically generated 12x12x12 grid of k-points following the convention of Monkhorst and Pack[36], and Marzari-Vanderbilt[37] scheme of smearing with the value of 0.0074 Ryd was used. For calculation of the density of states and energy bands, a dense grid of 24x24x24 grid was used.

Results and Discussions

The lattice constant was relaxed from 9.5 a.u. to 11.8 a.u. and the energy was calculated as a function of lattice constant. The data was then fitted to the empirical Murnaghan's equation of state (EOS)[38], which also gives the pressure at different lattice constants. A graph was plotted for the above data as shown in Figure 1 (in the plot we have shown only a small region of our interest) and from the plot, the lattice constants were taken for pressures from -10 GPa to 10 GPa with an increment of 5 GPa as given in table 1.

We studied the spin-polarized electronic band structures for Mn_2ZnSi along the high symmetric directions of the Brillouin Zone as a function of pressure(Figure 2 a-e). We brought down the Fermi level to zero and correspondingly all the energy levels were brought down by the same amount. Except for -10 GPa pressures, the band structures for all the pressures have the same character. The spin-up band structures have a continuous band across the E_F showing the metallic nature whereas the spin-down band structures have a discontinuity or a gap near the E_F showing the semiconducting nature. Thus, for these pressures, the Mn_2ZnSi shows a half-metallic bahaviour. The band gap for all pressures are direct with maxima of the valence band and minima of the conduction band at the same k-point, i.e. at L. For -10 GPa pressure, the E_F crosses the conduction band and there is a band gap just below the E_F. The band gap as a function of pressure is plotted in the figure 2 f. It can be seen that the band gap decreases on both sides of 0 GPa pressure.

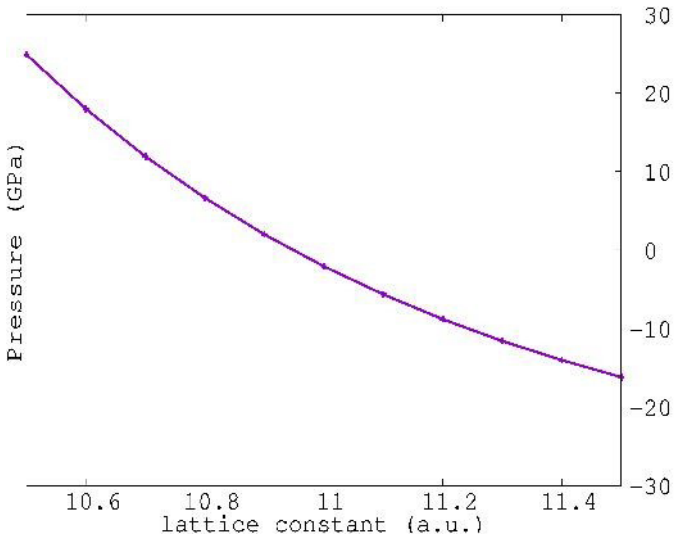

Figure 1: Lattice constant vs pressure

Table 1. Lattice constant at different pressures.

Pressure (GPa)	-10.00	-5.00	0.00	5.00	10.00
Lattice constant (Å)	11.2218	11.08	10.949	10.8361	10.7367

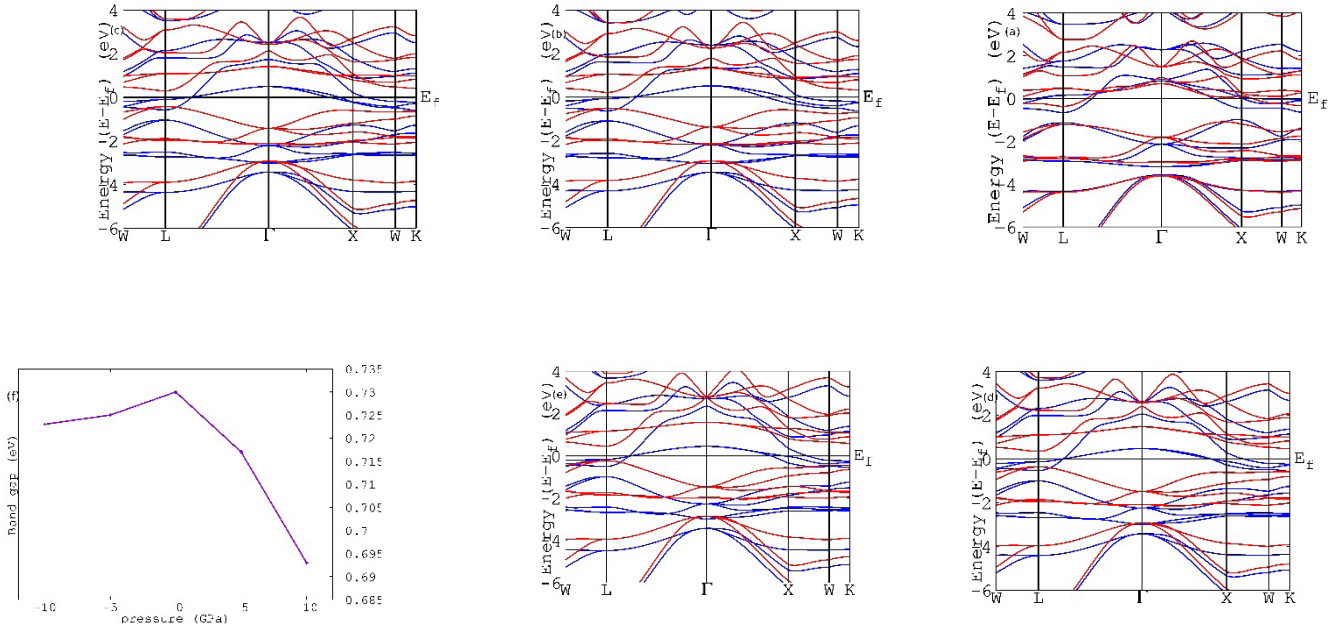

Figure 2: Electronic band structures along the high-symmetry k-path of the Brillouin zone (blue color for spin-up and red color for spin-down) (a) -10 GPa, (b) -5 GPa, (c) 0.0 GPa, (d) 5 GPa, (e) 10 GPa and (f) pressure dependence of band gap

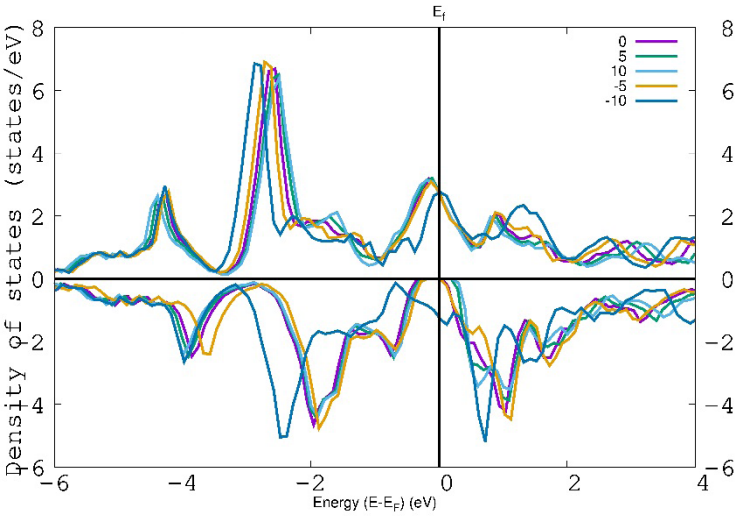

Figure 3: Density of states for different pressures

We also computed the spin-polarized density of states (DOS) as a function of pressure and plotted in figure 3. Positive axis for spin-up electron DOS and negative axis for spin-down electron DOS. The DOS for different pressures matches the band structures. Except for -10 Gpa, the others show the half-metallic behaviour. For spin-up electrons, the DOS are continuous across the E_F, showing the metallic behaviour. For spin-down electrons, the DOS have a semiconducting gap at the E_F,showing the semiconducting nature. Thus the DOS confirms the half-metallicity. Also, the DOS shows the variation of band gap with pressure. The DOS for -10 GPa shows no gap at the E_F.

The calculated total and partial magnetic moments of Mn_2ZnSi at different pressures are given in table 2.

Table 2. Total and partial magnetic moments at different pressures.

Pressure (GPa)	Magnetic Moment in μ_B				
	MnI	**MnII**	**Zn**	**Si**	**Total**
-10	-2.6191	3.577	-0.0257	0.1297	1.11
-5	-1.5207	3.4228	0.0122	0.085	1.98
0	-1.2795	3.2133	0.0088	0.0593	2.00
5	-1.0799	3.0371	0.0063	0.04	2.00
10	-0.8587	2.8384	0.0041	0.0216	2.00

From table 2, we can see that the contribution to the total magnetic moment comes mostly from Mn atoms and the contribution from Zn and Si atoms are negligible. With the increase in pressure the total magnetic moment increases and become constant at 2 $\mu_B$following the Slater-Pauling rule. Also, the Mn moment decreases in magnitude with the increase of pressure. Moreover, the Mn atoms coupled anti-parallelly giving a ferrimagnetic state.

Conclusions

We investigated the electronic structure and magnetic properties of Hg_2TiCu type full-Heusler alloy Mn_2ZnSi using plane wave pseudo potential and FP-LAPW method within spin-polarized generalized gradient approximation as a function of pressure. The computed spin-polarized electronic structure and DOS at the equlibrium lattice constants showed the half-metallic nature of Mn_2ZnSi with 100% polarization at E_F for all the presures except for -10 GPa. The band-gap is maximum at 0 GPa and decreases on both sides. The total and partial magnetic moments of Mn_2ZnSi were found to vary linearly with pressure. For some pressures the magnetic moment also found to follow the $M_T=Z_T$-28 Slater-Pauling rule.

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Effect of food substrates on nutrient content, production and economics of low cost vermicompost

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Abstract

On farm trials (OFT) were conducted at seven farmers' vermicompost units of West and South West Garo Hill districts of Meghalaya during 2015-16 to assess the nutrient content, production and economics of low cost vermicompost using different food substrates. i.e, vegetable based waste, banana pseudostem and arecanut leaves. Results revealed that the higher significant values were recorded in vermicompost produced from banana pseudostem incorporating cow dung in terms of production (2.04 t/unit/yr), net return (Rs. 17675/unit/yr) with a benefit cost ratio of (4.51:1) as compared to other food substrates. Significantly lower production of vermicompost was obtained from arecanut leaves. Among the three treatments, nutrient analysis of vermicomposts clearly showed that the vermicompost produced from arecanut leaves contained maximum amount of pH, organic C, total N and total K though the phosphorous content was maximum in vermicompost from banana pseudostem. Lowest nutrient content was observed in vermicompost of vegetable based waste. It can be concluded that among the three food substrates, vermicompost from banana pseudostem produced the highest with less duration required whereas, arecanut leaves substrate is best for its nutrient value.

Key words: Vermicompost, Banana Pseudostem, Arecanut leaves, Vegetable based waste, Nutrient value

Introduction

Vermicomposting is the process by which earthworms are used to convert organic wastes into humus like material known as vermicompost which is rich with various essential plant nutrients. This technology has been widely used as an organic waste management technique (Manyuchi and Nyamunokora, 2014; Manyuchi *et al*., 2014; Manyuchi and Phiri, 2013). Vermicompost is rich organic manure consists of macro and micro nutrients, plant growth promoting substances, beneficial microorganisms that are necessary for plant growth (Ghosh *et al.,* 1999). Organic wastes can be converted into valuable wealth by applying vermicomposting technology. Different biodegradable wastes (agricultural wastes, municipal solid wastes, animal wastes etc.) can be converted into useful substances by recycling process in agriculture, because they contain different types of plant nutrients. As the human population increases, a huge amount of agricultural wastes are found very commonly in large quantities which can be used in vermicomposting. Depending on the type of food substrates used, the nutrient content of vermicompost also varies. Present paper deals with the effect of nutrient content, production and economics of low cost vermicompost using three different food substrates viz. banana pseudostem, arecanut leaves and vegetable based substrate (mixture of kitchen wastes including onion, tomato, cabbage and cauliflower peels).

Material and Methods

On farm trials were conducted at seven farmers' vermicompost units of West and South West Garo Hills district, Meghalaya during 2015-16 using three treatments i.e. T_1- Vegetable based waste + Cow dung (3:1 ratio), T_2- Banana pseudostem + Cow dung (3:1 ratio) and T_3- Arecanut leaves + Cow dung (3:1 ratio). A low cost vermiculture structure was constructed using vermibed silpaulin (250µ) with size of length 6ft, breadth 4ft and depth 2ft at farmers of Bokmagre, Aminda Rangsa, Marapara, Rimrangpara, Asanang and Bhoirakupi villages of West and South West Garo Hills district. Bamboos and thatched grasses were used for roofing. A layer of 15-20 cm of dried straw was kept as bedding material. The processed wastes (food substrates) were filled (10-15cm) in a layer and kept wet while filling. A quantity of 0.5 kg (approx. 1000 nos.) of earthworm species (*Eisenia foetida*) were released in each treatment after the vermibed was filled up

with food substrates and cow dung in the ratio of 3:1. The food materials were kept moist (30-40%) by watering regularly and covered with gunny bags which help to reduce water loss and to maintain temperature. The observations were recorded at the time of harvest and samples were collected for analysis of chemical parameters of vermicompost. The nutrient parameters of vermicompost were analysed by using standard methods. Organic carbon was determined by the partially oxidation method (Walkley and Black, 1934). Nitrogen content (N) was estimated by Kjeldahl method (Bremner and Mulvaney, 1982). Phosphorus (P) was analysed using the colorimetric method (John, 1970). Potassium (K) was determined (acid digest) by flame photometer. The total cost of production was calculated by adding total variable cost and total fixed cost. The economics of vermicompost production was calculated by using the following formulas:

Gross cost (Rs.) = Total fixed cost (Rs.) + Total variable cost (Rs.)

Gross return (Rs.) = Price (Rs.) x Total quantity produced (Kg)

Net profit (Rs.) = Gross return (Rs.) - Gross cost (Rs.)

Benefit cost ratio (B: C) = Gross return (Rs.) / Gross cost (Rs.)

Results and Discussion

Days required and Yield of vermicompost

In the present study, vermicompost were prepared from three different food substrates viz. banana pseudostem, arecanut leaves, vegetable based waste using low cost silpaulin and locally available materials. It is clear from the observations that vermicomposts can be produced easily from different organic sources because the process of vermicomposts is easy and feasible in terms of material/cost required. Among the three treatments, the least number of days required for vermicomposting was observed in substrate using banana pseudostem (days) 56.0±5.41 while arecanut leaves required longer period (days) 90.1±4.22 as shown in Table 1. This may be due to the relatively low C: N ratio of banana pseudostem which makes more palatable and therefore readily accepted by earthworms. These results are in conformity with Manna *et al.* (2003). Arecanut leaves substrate required longer time to harvest as the leaves of arecanut are rich in lignin, cellulose and polyphenol content, and slowly biodegradable (Sujatha *et al.,* 2015). It was found from the recorded data that the yield of vermicompost is the highest in substrate using banana pseudostem (2.04t) and the lowest in arecanut leaves (1.17t) per unit per year. The difference in yield might be due to variation in biochemical composition of substrates which affects digestibility and decomposition of vermicompost.

Nutrient content of vermicompost

After the harvest of vermicompost from each treatment, the samples were collected for analyzing nutrient content. Vermicompost prepared using arecanut leaves recorded the highest values of pH (7.82±0.02), O.C (%) 10.45±1.05, N (%) 1.21±0.29, K (%) 0.94±0.45 than that prepared from banana pseudostem and vegetable based waste (Table 1). However, P (%) 1.92±0.16 was found to be slightly higher in banana pseudostem as compared to the other treatments. Loss of carbon and mineralization of organic matter resulted increased N content (Lakshmi *et al*. 2014). Increase in P content during vermicomposting is probably through mineralization and mobilization of phosphorus by bacterial and faecal phosphatase activity of earthworms Khwairakpam, 2009).

Table No.1. Average nutrient content and yield of vermicompost as affected by different substrates

Treatments	Days to harvest	Average production (t/unit/yr)	pH	O.C (%)	Total N (%)	Total P (%)	Total K (%)
T_1	69.7±4.68	1.56±0.10	5.67±0.07	6.20±0.87	0.77±0.14	1.35±0.27	0.54±0.09
T_2	56.0±5.41	2.04±0.14	6.48±0.04	8.36±0.81	0.96±0.25	1.92±0.16	0.71±0.45
T_3	90.1±4.22	1.17±0.18	7.82±0.02	10.45±1.05	1.21±0.29	1.78±0.45	0.94±0.45

All values are the mean and standard deviation of seven replicates

Economics

Among the three treatments under trial, the highest benefit cost ratio was recorded in vermicompost produced from substrate banana pseudostem (4.51: 1) followed by vegetable based waste (3.93:1) and arecanut leaves (2.42:1) as shown in Table 2. The variation in gross cost incurred under treatment T_2 and T_3 is higher than T_1 due to more number of mandays involved for chopping of banana pseudostem and arecanut leaves as compared to vegetable based waste.

Table No.2. Economics of low cost vermicomposting unit

Treatments	Gross cost (Rs.)/ unit/yr	Gross return (Rs.)/unit/yr	Net return (Rs.)/ unit/yr	B:C ratio
T_1	4657	18310	13653	3.93
T_2	5035	22710	17675	4.51
T_3	5602	13590	7988	2.42

All values are the mean of seven replicates

Conclusion

From the present study it can be concluded that among all the food substrates used for vermicomposting, banana pseudostem was found to be the most suitable in Garo Hills of Meghalaya. Due to short period required for production of vermicompost in banana pseudostem, it can be harvested four times a year. The vermicompost produced from arecanut leaves contained better amount of nutrients. However, the P content was recorded highest in vermicompost prepared from banana pseudostem. The benefit cost ratio of all the treatments indicates that by adopting low cost vermicompost production technology the farmers can get substantial benefit and augment farm income.

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Management of tomato leaf curl virus disease in tomato (var.Rupali) under West Garo Hills condition of Meghalaya, India.

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Abstract

Tomato leaf curl viral disease (TLCVD) is one of the most important viral diseases of tomato. It is caused by Gemini virus and spread by insect white fly (*Bemisia tabaci* Genn) which acts as the vector of the disease. Hence a study was conducted at ICAR, KVK farm of West Garo Hills during 2012-13 to evaluate different physical barriers and sprays for management of vector *Bemesia tabaci* and tomato leaf curl virus disease on tomato. Six different treatments were used for the study. In the nursery the seedlings raised under nylon net covering and nylon net barrier of 90 cm height around the nursery bed showed no incidence of TLCV disease three weeks after sowing whereas yellow sticky polythene sheet, spraying with Neem oil 3ml/litre and 0.05 percent chlorpyriphos showed 6.66, 6.66 and 5.33 percent infection respectively.

Seedlings raised under completely covered nursery bed when transplanted in the main field showed least incidence of disease (15.30 percent) and highest yield 228.58 q/ha followed by seedlings raised under nylon net barrier of 90 cm height (19.33 percent and 197.33 q/ha) respectively as compared to untreated control where disease incidence was 63 percent and yield 126.66 q/ha. Thus, seedlings from these two treatments when transplanted in the main field although could not prevent hundred percent infection of the crop but certainly had an impact in delaying the incidence of TLCV and increase yield over other treatments where as 63 percent disease incidence was recorded in the untreated plots.

Key words: Tomato, TLCV, whitefly, physical barriers, sprays

Introduction

Tomato cultivation has become more popular since the mid nineteenth century because of its varied climatic tolerance and high nutritive value. The area under tomato cultivation in the world is about 28.52 lakh hectares with an annual production of 77540 lakh tonnes (Anonymous, 1993).In India tomato is grown throughout the country occupying an area of 13.5 thousand hectare accounting for 3.12 lakh tonnes fruits (Anonymous, 1995).In West Garo Hills tomato is grown in an area of 150 hectare with an average yield of 17493 kg/ha.(Source: Directorate of Horticulture ,Meghalaya)

The major constraint to the cultivation of tomato is that it is infected by a number of diseases, which causes substantial yield loss. Besides fungal, bacterial and nematode disease it is also affected by large number of viral diseases (Anonymous, 1993). Among the viral diseases, tomato leaf curl virus disease (TLCVD) is the most destructive in many parts of India which causes serious yield losses upto 70 percent or more depending on the stage at which the crop was infected (Muniyappa and Saikia, 1993; Saikia and Muniyappa, 1989).

The disease is characterized by curling and twisting of the leaves followed by marked reduction in leaf size. The diseases plants look pale and stunted due to shortening of internodes with more lateral branches resulting in bushy appearance. TLCVD is caused by tomato leaf curl Gemini virus (Muniyappa *et.al*., 1991).The whitefly (*Bemisia tabaci*Genn) has been proved to be the vector of TLCV (Butter and Ratual, 1977). *B. tabaci* is an aleyrodidae, which currently has become the most serious pest causing direct damage apart from its devastating role as a vector of plant viruses, in particular Gemini viruses. Thus it considerably reduces crop yield, resulting in huge financial losses. In the recent past, over reliance on conventional insecticides for the control of *B.tabaci* has resulted in the emergence of several new highly resistant and polyphagous strains of whiteflies. Furthermore the resistant strains can produce more than three times as many eggs as the original strain. (cook,1986).The development of alternative management practices is therefore extremely important to prevent evolution of aggressive biotype of *B.tabaci* and thereby reduce the spread of the disease which are vectored by the insects. Taking this background into account the present investigation aims to explore the potential of physical barriers, insecticide

and Neem oil for the management of vector *B.tabaci* in relation to the spread of the disease in tomato.

Materials and Methods:

Tomato variety: Rupali

Six beds of 1sqm were prepared and raised to 10-15cm above the ground level followed by adding of 3 kg compost was added and brought to fine tilth. About 300 seeds of the variety kalash were sown in u shaped furrows at a depth of 1-2 cm on 5th November 2012. The seeds were then covered immediately with a thin layer of soil mixed with well dried and sieved cowdung. Six treatments namely T_1 (covering the nursery bed with insect proof white nylon net (40 mesh); T_2 (yellow sticky polythene sheet around the uncovered nursery bed; T_3 (Spraying the seedlings with 0.05 percent chlorpyriphos in the nursery bed. First spray at 12 days after sowing and second spray at 24 days after sowing; T_4 (spraying the nursery seedlings twice with Neem oil 3ml/litre (10000ppm). First spray at 12 days after sowing and second spray at 24 days after sowing; T_5 (insect proof white nylon net 40 mesh barrier of 90cm height around the nursery bed and T_6 (untreated control).

25 days old seedlings were transplanted in plots of 3m×3m of the main field at a spacing of 60cm × 45 cm on 2nd December 2012. The experiment was laid out in randomized block design with 6 treatments and 4 replications.

Recording of TLCV disease incidence and white fly: Each plant was regularly inspected for the first appearance of TLCV disease. The disease was recorded for 12 consecutive weeks at weekly interval in the main field. The development of typical TLCV symptoms were recorded as incidence i.e., % of infected plants and illustrated graphically. The Area Under Disease Progress Curve (AUDPC) for each treatment was enumerated using the formula state below and analyzed statistically.

$$AUDPC = \sum_{i=1}^{n} \{(Y_i + Y_{i+1})/2\} \times (t_{i+1} - t_i)\}$$

Symptom development was evaluated according to the symptom severity scale described by Friedmann et al. as follows:

0 = no visible symptoms,

Inoculated plants show same growth and development as noninoculated Plants;

1 = very slight yellowing of leaflet margins on Apical leaf;

2 = some yellowing and minor curling of leaflet ends

3 = a wide range of leaf yellowing, curling and cupping, with some reduction in size, yet plants continue to develop;

4 = very severe plant stunting and yellowing, pronounced leaf cupping and curling and

5= plant growth stops.

In nursery the disease was recorded for three weeks at an interval of 7 days.

White fly population was recorded in the nursery only. Ten plants per treatment were selected randomly for counting whitefly by Direct count method.

Results and Discussion

Treatments	Number of seedlings examined	7 days		14 days		21 days		Percent infection of TLCV
		No of white fly recorded	No of seedlings showed TLCV symptom	No of white fly recorded	No of seedlings showed TLCV symptom	No of white fly recorded	No of seedlings showed TLCV symptom	
T1	75	0	0	0	0	0	0	0
T2	75	0	0	0	0	5	5	6.66
T3	75	0	0	0	0	5	4	5.33
T4	75	0	0	0	0	6	5	6.66
T5	75	0	0	0	0	0	0	0
T6	75	0	0	0	0	10	12	16

Table1. Effect of different treatments employed in the nursery bed on TLCV incidence

T_1 (covering the nursery bed with insect proof white nylon net (40 mesh)

T_2 (yellow sticky polythene sheet around the uncovered nursery bed

T_3 (Spraying the seedlings with 0.05 percent chlorpyriphos in the nursery bed

T_4 (spraying the nursery seedlings with Neem oil 3ml/litre(10000ppm)

T_5 (insect proof white nylon net (40 mesh) barrier of 90cm height around the nursery bed)

T_6 (untreated control).

Table 2. Effect of different treatments employed in the nursery bed on TLCV incidence under field condition

Week / **Treatment**	TLCV incidence recorded weekly after planting (%) and AUDPC													
	1	2	3	4	5	6	7	8	9	10	11	12	AUDPC	Percent disease reduction over control
T_1	0	0	0	0	2.67	2.67	4.3	5.45	8.33	10.33	10.33	15.30	228.58	75.71
T_2	0	0	0	3.33	4.66	6.67	11.67	15.00	15.00	21.67	25.00	29.33	179.37	53.44
T_3	0	0	0	1.67	6.67	10.00	10.00	13.33	18.33	20.00	23.33	27.67	188.90	56.07
T_4	0	1.67	3.33	6.67	8.33	10.00	13.33	15.33	23.33	30.00	35.00	42.67	157.66	32.33
T_5	0	0	0	0	3.33	4.66	5.00	8.33	11.67	11.67	15.00	19.33	197.33	69.31
T_6	4.66	8.33	13.33	15.00	21.67	28.33	33.33	38.33	45.33	50.67	55.33	63.00	126.66	
													10.47	
SEm±													6.79	
CD(P=0.05)													21.68	

(Data are mean of four replications)

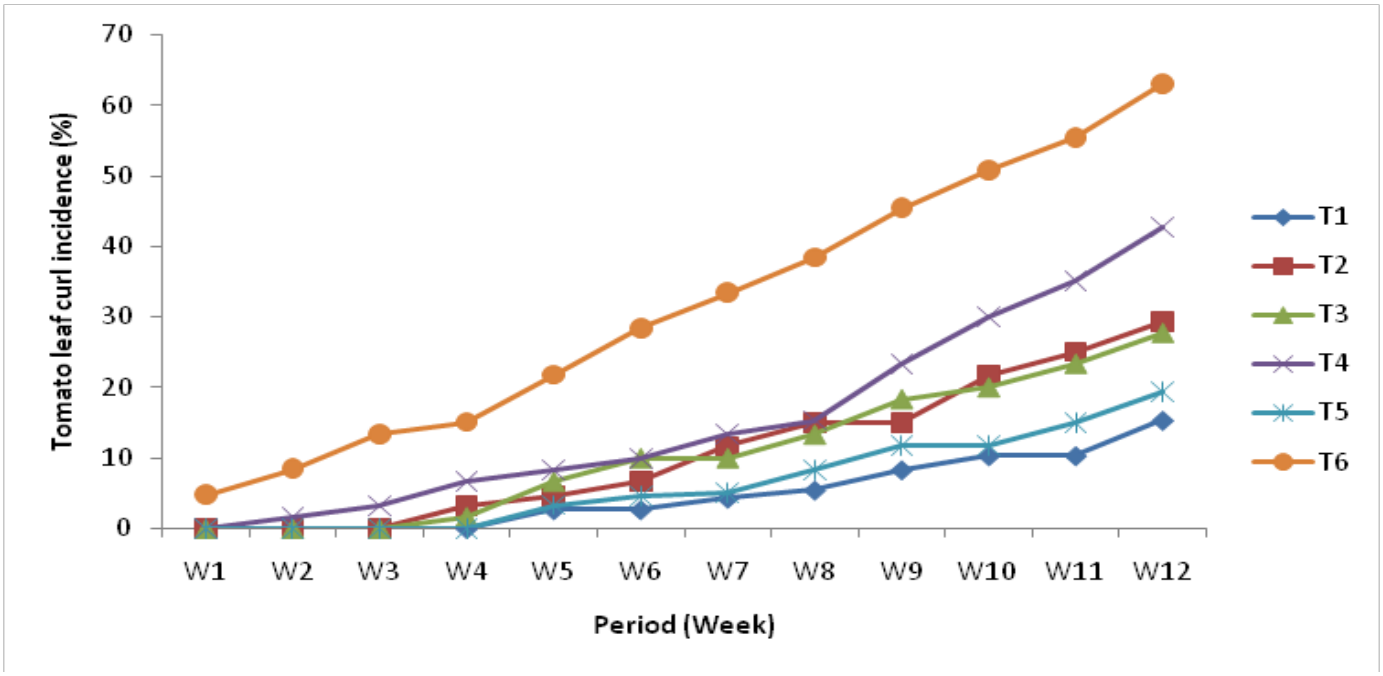

Fig.1 Incidence of TLCVD upto twelve weeks after planting (%)

Table 3. Effect of different treatments employed in the nursery bed on TLCV incidence and yield

Treatments	TLCV (%) at terminal stage of disease record	AUDPC	Yield (q/ha)	Percent increase of yield over control at terminal stage
T_1	15.30	53.73	228.58	80.47
T_2	29.33	102.66	179.37	41.61
T_3	27.67	96.85	188.90	49.14
T_4	42.67	149.35	157.66	24.47
T_5	19.33	67.66	197.33	55.79
T_6	63.00	204.19	126.66	
SEm±		6.79	10.47	
CD (P=0.05)		21.68	33.40	

From the data presented in Table 1 it was evident that in all the treatments the white fly population and TLCV incidence were zero upto 14 days after sowing (DAS).When the observations were made at 21 days the untreated control showed maximum TLCV incidence (16%)and highest number of whitefly population (10 nos) followed by treatment T_2(yellow sticky polythene sheet around the nursery) and T_4(Spraying the nursery seedling with 10000ppm neem oil 3ml/litre of water) indicating 6.66 percent TLCV incidence in both the treatment and whitefly population of 5 and 6 respectively. However in treatment T_3 (0.05% Chlorpyriphos) the TLCV infection was 5.33%. It was found that treatments T_1 (nylon net covering) and T_5 (nylon net barrier of 90 cm height) revealed the best amongst the treatments where all the plants were free from TLCV infection with no record of white fly.

Data presented in Table 2 reveals that the disease incidence in all the treated plots varied from 15.30 to 63% after 12 weeks of planting. The percent reduction of disease over control was the highest in nylon net covering (75.71%) followed by nylon net barrier of 90 cm height (69.31%) while the lowest was observed in treatment T4 (Spraying the nurs-

ery seedling with 10000ppm neem oil 3ml/litre of water) i.e 32.33%.Lowest AUDPC was observed in treatment $T_1$and T_5(53.73 and 204.19) respectively and differed significantly with other treatments. Also from Fig.1 it was evident that lowest incidence of TLCVD was observed in treatment T_1 (covering the nursery bed with insect proof white nylon net (40 mesh) and T_5 (insect proof white nylon net 40 mesh barrier of 90cm height around the nursery bed) as compared to other treatments.

Results presented in table 3 revealed that tomato yield was significantly increased as the disease incidence decreased in the treatments. Treatment T_1 gave the highest yield and lowest incidence of disease at terminal stage of disease record as well as lowest AUDPC (228.58q/ha , 80.47% and 53.73)) followed by treatment T5 (197.33q/ha, 69.31% 67.66).The lowest yield of 126.66q/ha was recorded in untreated control along with highest TLCVD(63%) and AUDPC(204.19). The increase in yield over control recorded a maximum of 80.47 % in treatment T_1 followed by T_5.The overall variations in yield in all the treated plots ranged from 157.66 to 228.58q/ha percent reduction of disease over control from 32.33 to 75.71 percent as presented in Table 3 and 2 respectively.

Conclusion

The effect of different treatments in the nursery beds revealed that the seedlings in the nursery bed protected with nylon net covering(T_1) and nylon net barrier (T_5) against the vector *B.tabaci* greatly reduced the percentage of TLCV incidence and proved to be the best amongst the treatments.This results conform to those described by Saikia and Muniyappa 1989.Field observation showed that even though the nursery treatment did not prevent hundred percent infection of the crop ,nylon net covering and nylon net barrier certainly had an impact in delaying the incidence of TLCV to certain extent and they did increase yields significantly.The maximum TLCV incidence was observed in untreated control.The incidence reached the peak of 63 percent 12 weeks after planting.

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Diversity of wood fungi in forest of Garo Hills with special reference to parasitic forms

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Abstract

The Garo Hills cover 60% of the total forest area in Meghalaya. It is richly endowed by nature, with trees, shrubs and herbs and fungi. A wood decay fungus is any species of fungus which causes rot. Some of the wood fungi like *Polyporus*, *Ganoderma* etc. attack and damage wood structure.

Keywords: Wood fungi, disease, pathogen, forest

Introduction

The Garo Hills having an area of approximately 8000 sq. kms is densely forested and hence are one of the richest spots in biodiversity. A variety number of trees, shrubs, herbs, ferns, as well as fungi are found in this area. A wood decay fungus is a species of fungus that digest moist wood causing it to rot. Some of these species attack living plants and are known as parasitic forms.

Materials and Methods

This research is conducted in the forests of Garo Hills. The diseased material (wood fungi) of a particular plant was collected in sterile polythene bags separately.

To obtain clear knowledge of disease symptoms and for identification, the pathogen were grown in different culture media like Potato Dextrose Agar, Richard's Agar and Czapek Dox Agar Medium.

Result and Discussion

(1) **Name of the host plant**: Teak (*Tectona grandis*)

(a) Type of disease: Root rot

(b) Symptoms of the disease: The fungus eventually migrates from decayed stumps into the shoots and also progresses into roots up to the distal ends from where healthy roots of adjoining trees coming in contact with them become infected. It attacks heartwood though sometimes sapwood also is attacked. In the early stages the fungus causes white mottled rot with orange-yellow lines. Eventually, pockets develop in the bleached trees. Fungus causes roots and butt rot. Small light yellow mycelial felts of the fungus develop on the bark of the roots (Plate 1)

(c) Morphology of the Pathogen and Identification

The sporophores of the fungus develops at the base of the trees in imbricate clusters. Sporophores are usually sessile, leathery when fresh, hard and rigid when dry. Upper surface is pinkish-buff when young, becomes reddish brown with age and is concentrically zonate. Lower surface is white to pinkish with a silky cover. Basidia clavate 4.5 - 6.7 um broad, basidiospore hyaline measuring approximately 9-14 x 6-8 um. It is a wood parasite. Infection may originate from the nursery stock and therefore only healthy stumps should be selected for planting (Plate 2).

The pathogen was identified as *Polyporus zonalis*. It was also reported by Bakshi, Sujan Singha and Ujagar Singh in 1965.

It was also reported by Bakshi, Reddy, Puri and Sujan Singh in 1972. The same disease was collected from almost all reserved forests of Garo Hills and their detail account is the same as described here.

Plate 1 :- Infected plant
Plate 2: Single sporophore

(2) **Name of the host plant**: Sissoo (*Dalbergia sissoo*)

(a) **Type of disease**: Root rot of sissoo

(b) **Symptoms of disease**: Infection due to this fungus maybe traced back to residual stumps and root of the previous forest cover. The pathogen attacks and kills the bark and causes white spongy rot in the sapwood. Sometime infection takes place through intact as well as injured surfaces. Affected plants exhibits pale foliage which eventually dries up. Young plants are killed soon after infection. Mature trees are also killed when most of the roots become affected. The fungus produces thin white mycelial mat between the bark and the wood. It possesses ectotrophic growth in the form of small, thin mycelial aggregates on bark of roots and also on solid objects, like stones and soil lumps which are in direct contact with infected roots. It does not possess any free mycelial spread in the soil. Fruit body (sporophore) of the pathogen commonly develops on affected plants, usually at the base. The same symptoms were observed in all reserved forests especially in three years (Plate 3).

(c) **Morphology of the pathogen and Identification**: The pathogen infects roots through intact as well as injured surface. Mycelium is both inter and intracellular and consists of very fine, much branched, septate, hyaline hyphae having the clamp connections. Fruit bodies of pathogen develop on affected plants, usually at the base or apparently on the ground but in the latter case, the sporophores are invariably attacked to decayed roots. Due to presence of sporophores, it is easy to locate the infected plants. Sporophores are usually stalked, rarely sessile, corky, later woody. Stalk and upper surface are shiny laccate, lightly zoned. Hymenial surface is white when fresh turning light brown on drying, pores minute (Plate 4).

The pathogen was identified as *Ganoderma lucidum*. It was also reported by Bakshi and Sujan Singh, 1972.

Plate 3: Infected tree

Plate 4: Single sporophore

(3) **Name of the host plant**: Sissoo (*Dalbergia sissoo*)

(a) **Type of disease**: Root rot of sissoo

(b) **Symptoms of disease**: The pathogen is primarily a wound parasite and mostly attacks sissoo in plantations and maybe in association and maybe found in association with *G.lucidum* or the wilt pathogen *F. solani*. Trees of advanced age are attacked. Af-

fected trees exhibit stage headed conditions. Sporophores which develop readily on root and stem bases. The fungus causes restricted decay as white rot in sapwood and to a limited etentin the heartwood. The sporophores develop commonly on trees at the collar region or apparently on soil but then attacked to roots or a woody food-base. The fungus produces on the root thin, white mycelial sheets between the bark and the wood. The mycelium may travel from the root to the bulk region where sporophores usually develop. The fungus produces white pocket rot in the wood (Plate 5).

(c) **Morphology of the pathogen and identification**: Vegetative body of the pathogen is mycelium, which is both inter and intracellular. Mycelium is very fine and branched, septate, hyaline hyphae having clamp connections usually. Sporophore or fruiting body which develop readily on root and stem bases are sessile brown and corky. The sessile sporophores are without stalk, and their point of attachment to the substratum is lateral and hence they look like a bracket, shelf or knob. Normally sporophore is corky or fleshy bracket, shelfor knob. Normally sporophore is corky or fleshy in texture; when dry the sporophore becomes hard (Plate 6).

The pathogen was identified as *Polyporus gilvus*. It was also reported by Browne, 1968 and Bakshi, 1971.

The disease was collected from forests of Garo hills in all three years.

Plate 5 :- Infected Tree

Plate 6: Single sporophore

Conclusion

These three different types of parasitic wood fungi such as *Polyporus zonalis*, *Ganoderma lucidum* and *Polyporus gilvus* are found in the trees growing in the forests of Garo Hills. They attack and damage completely destroy the wood structure and quality of the wood.

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Impact of bank finance on income and employment of composite fish culture in Sivasagar district of Assam

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Abstract

The present study attempts to examine the Impact of Bank Finance on Income and Employment of Composite Fish culture in Sivasagar district of Assam. The study was based on primary data collected through pre-tested schedule by the personal interview method of sampling of 150 borrowers and 150 non-borrowers from three size groups based on area under fishery by using cumulative root frequency rule,group I (34 borrowers and 62 non-borrowers), group II (85borrowers and63 non-borrowers) and group III (31 borrowers and 25 non-borrowers). The result showed that the bank finance and other financial institution create an impact on borrower's income. On an average, the borrower's income increased by Rs. 14027.3 accounting for 11.80 per cent. The regression co-efficient of the bank loan was positive and statistically significant at 5% probability level in all the size groups of borrowers. The variable bank finance explained about 66, 65 and 71 per cent variation in the fishery income of borrowers of farm size group I, II and III respectively and 45, 79 and 20 per cent variation in the employment generation of borrowers of farm size group I, II and III respectively.

Key words: Bank finance, Impact, Income and Employment, borrowers and non-borrowers.

Introduction

In Sivasagar District of Assam, Fishery is one of the important economic activities of the people living in rural areas. It has been estimated that around 25,000 persons were engage in this activity with full time or part time employment in the district. There is tremendous potential for development of fisheries with the available natural resource such as beels, derelict water bodies, low-lying areas, rivers, ancient tanks, ponds, etc. shown in table 1 'The District produces 9610 tonnes of fish against 243869 tonnes of fish in Assam. Moreover it produces 44 million nos. of fish seed as against 4490 million nos. in Assam in 2011-12' (Anonymous, 2012). There are 1 government and 3 private fish hatchery and 4 eco hatchery in the district.

Materials and Methods

The study was conducted in the Sivasagar district of Upper Assam covering 150 samples borrowers and 150 non-borrowers being selected from the three size groups based on area under fishery by using cumulative root frequency rule. Thus the distribution of sample borrowers and non-borrowers constituted 34 and 62 in group I, 85 and 63 in group II and 31 and 25 in group III. The primary data was collected with the help of pre-tested schedule by the personal interview method of sampling.

The collected data was tabulated and analyzed by tabular and regression equation. The impact of bank finance on borrower's income was examined by (i) Difference in total income from all sources including fishery with that of non-borrowers and (ii) Regression analysis of both simple and multiple regression equation.

The impact of bank finance on employment was examined by Regression analysis. The equation is as follows:

(i) $Y_1 = a + bx + e$

(ii) $Y_2 = b_o + b_1x_1 + b_2x_2 + b_3x_3 + b_4D_4 + e$

Where,

Y_1 = Employment in man days

Y_1 = Income from fishery of the borrowers (Rs)

$Y_{2 =}$ Income from fishery of the borrowers and non-borrowers (Rs)

x = Amount of bank finance (Rs)

x_1 = Expenditure in fingerlings (Rs)

x_2 = Expenditure on feed (Rs)

x_3 =Expenditure on labour

D_4= Dummy for sample farmers with a value of 1 if the farmer owns a loan (borrowers) and a value of 0 otherwise (non-borrowers)

e = Error term

a, b. $b_o$and $b_1$tob_4 are the unknown parameters estimated with the help of Ordinary Least-Square Method (OLS). Positive and statistically significant regression co-efficient (parameter)such as b and b_4 would indicate the impact of bank finance on the income of borrowers for the sample and multiple regression analysis respectively.

Result and Discussion

Impact of bank finance on income of the fish farmers:

Table I, showed that the per farm income of borrowers and non-borrowers from all sources including fishery with the resulting difference under different size groups of farm. The income considered here was the whole farm income comprising income from field crops, livestock, plantation crops and that of fishery for which the loan and subsidies were given. The table reveals that on an average the borrower's income increased by Rs. 14027.3 and there by accounting for 11.80 per cent increase over the non-borrowers income. Between different size groups also, the borrowers income in absolute term found to be more than that of non-borrowers income. The magnitude was found to be increased with the increase in farm size which varied from Rs. 8191.9 in the farm size group I to Rs. 23362.2 in size group III. The increase in income in terms of percentage seemed to be highest in group I (12.52 per cent) and lowest in group II farm (10.96 per cent). Further, the increase in income in all the size groups of borrowers including average situation was found to be statistically significant at 5 per cent probability level.

The result of the simple linear regression analysis reveals that the regression coefficient of the bank loan was positive and statistically significant at 5% probability level in all the size groups of borrowers. This indicate the fact that bank finance had significantly impact on borrower's income. The variable bank finance explained about 66, 65 and 71 per cent variation in the fishery income of borrowers of farm size group I, II and III respectively (Table II). Likewise multiple regression analysis showed a positive relationship of the sample borrowers owing the loan dummy variable with the fishery income in all the size group of borrowers. This also indicate that the bank finance has significant impact on borrower's income. The variable bank finance explained about 77, 84 and 39 per cent variation in the fishery income of borrowers and non-borrowers of farm size group I, II and III respectively (Table III).

Impact of bank finance on employment of the fish farmers:

The result of the regression co-efficient of the bank loan on employment was positive and statistically significant at 5% probability level in all the size groups of borrowers. This indicate the fact that bank finance had significant impact on employment. The variable bank finance explained about 45, 79 and 20 per cent variation in the employment generation of borrowers of farm size group I, II and III respectively. The results, thus showed that the bank finance increase the income and employment of borrowers fish farmers in the study area (Table IV).

Conclusion

The bank finance had significantly increased the income of fish farmers in the study area. The increase inborrowers income over non borrowers income was found to be in between 10 to 13 per cent among the various size group of farm. On an average it was 11.80 per cent. The results also confirmed by the simpleand multiple linear regression analysis. The variable bank finance explained about 66, 65 and 71 per cent variation (simple regression) and 77, 84 and 39 per cent variation (multiple regression) in the fishery income of borrowers whichindicates a positive and statistically significant at 5% probability level in all the size groups of borrowers. Moreover impact of bank finance on employment was also found to be positive and statistically significant at 5% probability level in all the size groups of borrowers. Which indicates that the bank finance had significant impact on employment. The variable bank finance explained about 45, 79 and 20 per cent variation in the employment generation among different size groups of borrowers.

Table I. Income generation due to finance in different size groups of borrowers (Rs. Per farm):

Size groups	Income of borrowers	Income of non-borrowers	Increase of borrowers income over non-borrowers	percentage increase in income
Group I	73645.0	65453.1	8191.9	12.52
Group II	88758.2	79991.6	8766.6	10.96
Group III	236261.3	212899.1	23362.2	10.97
Average	132888.2	118860.9	14027.3	11.80

Table II. Results of simple linear regression analysis for the impact of bank loan on income of the Various Size Groups of Borrowers:

size groups (ha)	Intercept	Regression Co-efficient	T-statistic	R2	n
Group I	569.1783	0.90694 (0.113385)	7.998784*	0.666599	34
Group II	588.9367	0.614619 (0.048963)	12.55266*	0.654985	85
Group III	3557.426	0.668385 (0.078027)	8.566032*	0.716733	31

*Significant at 5 per cent probability level.

Table III. Results of Multiple Linear Regression Analysis from fishery Income of the sample borrowers and non-borrowers in various size groups of farm:

	Group I		Group II		Group III		Farm as a whole	
variables	Regression Co-efficient	T- stat	Regression Co-efficient	T- stat	Regression Co-efficient	T- stat	Regression Co-efficient	T- stat
X1	6.667357 (1.394278)	4.781942*	1.614933 (0.51309)	3.147466*	2.761449 (1.076963)	2.564107*	6.383625 (0.574086)	11.11963*
X2	2.550678 (0.870392)	2.930495*	0.751599 (0.330561)	2.273709*	0.466631 (0.219024)	2.130507*	0.388078 (0.110711)	3.505323*
X3	0.82058 (0.213951)	3.835362*	0.061826 (0.182692)	0.735544	0.010998 (0.377107)	0.029164	0.576773 (0.171473)	3.363631*
D4	0.650821 (0.192187)	7.543781*	0.501723 (0.22981)	3.271894*	0.544807 (0.182174)	5.93306*	0.963274 (0.241364)	3.990968*
R2	0.77		0.84		0.39		0.70	

*Significant at 5 per cent probability level.

Table IV. Results of Simple Linear Regression Analysis for the Impact of bank Finance on Employment of the Various Size Groups of Borrowers:

size groups (ha)	Intercept	Regression Co-efficient	T-statistic	R2	n
Group I	23.14489	0.004593 (0.000898)	5.116544*	0.450	34
Group II	2.296545	0.00896 (0.000496)	18.07085*	0.797	85
Group III	38.70266	0.000356 (0.000131)	2.71436*	0.203	31

*Significant at 5 per cent probability level.

Suggestion

The bank finance was found to be beneficial to the sample borrowers than the non-borrowers, so bank should target those farmers which were not connected with the banking facilities. Moreover awareness camp about economic development through fishery could influence the farmers and other people toward fishery which could create employment in a large scale.

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Rice based indigenous beverage of tribes of West Garo Hills, Meghalaya, India

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Abstract

Rice is the staple cereal food for the tribal groups namely the *Garo, Hajong* and *Boro* of West Garo Hills, Meghalaya. Home brewed rice beverage plays a significant role in their lives. The fermented rice beverage constitutes an inherent part of their diet and culture. Its preparation involves the use of starter culture made using locally available medicinal plants and fermentation of boiled rice in earthen pots. These tribes have been practising the fermentation of rice immemorially and strongly believe in its potential curative properties. It has been a household art for centuries and is handed-down from one generation to the next. However, the product is prepared with rusticity without any noesis of good manufacturing practice (GMP). Scientific research on it is still naif embracing scope for research. Further, studies would accredit the native products by creating public sentience with respect to its nutritional and medicinal value. Setting up of a scientifically strategized small-scale unit, would assist the process of production on a larger scale, produce hygienic and high-quality value added stable products with enhanced shelf life and improved therapeutic properties thus helping to economically produce the beverage at reduced production costs by providing employment which would be a boost to the rural community of West Garo Hills.

Keywords: fermentation, tribes, medicinal value,

rice beverage

Introduction

The artistry of brewing beverages is, perhaps, as old as human history. Fermented beverages have always received a prominence status in human spiritual and cultural life both in Western and Eastern societies. A glance at the history of various cultures in different parts of the world will bring to light that consumption of fermented drink was a part of the daily diet. Historians have found evidence that fermented drink made of grapes, hawthorn berries, honey, and rice was being produced in 7000–6650 BC. In India, an alcoholic beverage called *Sura*, distilled from rice, was in use between 3000 and 2000 B.C. (Dasgupta 2011 and Chrzan 2013). Beverages fermented from rice are formerly exclusive to East Asian and Southeast Asian countries and is popular in countries like Japan, China, Philippines, Korea, and Vietnam and some parts of Central and North-eastern India. Herbal formulation for yeast culture for brewing alcoholic beverage from cereals is probably the most ancient method. Alcoholic rice beverage is an integral part of life of several aboriginal communities and is known in different names in different places. It is known as *sake* in Japan, *lao-chaoin* China, *tapeketan* in Indonesia, *khao-makin* Thailand, *ruoude* or *ruounepin* Vietnam, *makgeolli* in Korea. (Kim et al. 2013; Tatiana and Mari 2010; Deka and Sarma 2010; Dung 2013).

Fermenting rice by employing different starter cultures and locally available medicinal plants are called as *apong* by the Mising tribes, *juguli* by the Rabhas, *zu mai* by the Bodos, *kiad* by the Pnars, *zutho* by the Nagas, *sekmai yu* by the Manipuri Segmai, *chuwak* by the Tripuris and as *rokshi* in *Sikkim* (Deka and Sarma 2010; Dung 2013; Pegu et al. 2013; Brahma et al. 2014; Samati and Begum 2007; Teramoto et al. 2002; Singh and Singh 2006; Singh et al. 1999). While rice-based traditional beverages have different compositions according to the formulation and processes used, the principle of their manufacture can be characterized as a biochemical modification that is saccharification of cereal starches brought about by microorganisms in which fungi (yeasts and moulds) play essential roles. Moulds produce the amylases that degrade the starch into dextrins and sugars, and yeasts convert these sugars to alcohol. The preparation and the use of fermentation starters as a source of inoculum are important in the manufacture of rice beverage. These dried starters

normally include yeasts, moulds and bacteria and convert starchy materials to fermentable sugars and subsequently to alcohol and organic acids. The use of different starter cultures with varying microbial content and rice variety has been associated with the production of beverage with different tastes and flavours, the quantity and quality of beverage. Glutinous or sticky rice for instance is a rich source of starch, protein and various microelements that are used by microbes during the fermentation process to produce more beverages (Palaniveloo and Vairappan 2013).

Meghalaya is a tribal dominated state in north-east India. It covers an area of approximately 22,430 square kilometres, with a length to breadth ratio of about 3:1 and is the wettest state of India. It is mountainous, with stretches of valley and highland plateaus which is divided into three main parts viz. the central part of the plateau comprising the Khasi Hills, followed by the eastern section comprising the Jaintia Hills and the western section of the plateau comprising the of Garo Hills (Fig 1). Tribal people make up much of Meghalaya's population. These were among those known to the British as "hill tribes." The entire Garo Hills comprise an area of approximately 8,000 sq kms which is densely forested and is one of the richest spots in biodiversity. The Garo Hills is inhabited mainly by the Garo tribes who belong to the Bodo family of the Tibeto-Burman race tribes and espouse a matrilineal society (Miah 2012). The Garo community has a distinct dietary culture that symbolizes their heritage and ethnicity. Their staple food is rice, vegetable and meat. Also, home brewed rice beverage locally called '*bitchi'* occupies a significant position in their diet and in their culture. The rice beverage is an integral part of the tribal festivals and ceremonies. It is prepared in huge quantity during the celebration of the annual crop harvest festival where during the thanks giving ceremony rice beverage is offered to the gods and goddesses. It also commands great importance in entertaining guests at home. Sticky red rice variety called *menil* (*Oryza sativa* L.), is mostly used for beverage production as it has higher carbohydrate contents and imparts the desirable sweetness to the beverage. The rice is sometimes roasted to add an idyllic smoky flavour to the final product. There are two important locally available medicinal plants that are used by the Garos in the preparation of the starter rice cake. They are leaves and flowers of *Plumbago zeylanica* locally called *achetra* and leaves of the fern *Thelypteri sclarkei C.F. Reed* locally called *sarath*.

India, traditional brewed rice beverages are encountered across the central and north-eastern states, spanned with diversified ethnic groups who bear their own indigenous methods of

1a. Medicinal plants used in rice beverage preparation (Fig 2)

*P. zeylanica*is is a popular medicinal herb throughout Africa and Asia. It has been used as a remedy for skin diseases, infections and intestinal worms viz**.** leprosy, scabies, ringworm, hookworm, dermatitis, acne, sores and ulcers since time immemorial. Traditionally it is used as a stimulant digestive, expectorant, laxative and in the treatment of muscular pain and rheumatic diseases. Investigations have been carried out on different chemical compounds such as plumbagin and other compounds of this plant. Its biological activities like antibacterial, antimycotic, antiviral, antiplasmodial, leishmanicidal, trypanocidal and anticarcinogenic have been studied along with its pharmacological effect (Pant et al. 2012).

The fern *Thelypteri sclarkei C.F.Reed* is used by some Garo tribes in places where it is found profusely and when rice beverage with higher alcoholic percentage is preferred. However, such belief and the therapeutic value addition to the beverage by this fern are yet to be established. No literature was found to be available on the therapeutic properties of this fern.

The *Boro* and *Hajong* tribes of the West Garo Hills who are spread across the Tikrikilla Block mostly use the yellow rice variety called *mirong* locally available in the region and the leaves of the *Clorodendrum species namely Clorodendrum D.Don, Clerodendrum infortunatum L.* alllocally called as *samaki*. Also leaves of *Scoparia dulcis L*. (sweet broom), *Musa paradisiaca L* (banana), *Artocarpus heterophyllus*(jack fruit) and *Leucas lavandulifolia* are used in the starter cake preparation. The tribe use *Clorodendrum* D.Don in case of snake bite to heal the wound.

Ethno-medical importance of various species of *Clorodendrum* genus has been reported in various indigenous systems of medicines and as folk medicines. The genus is being used as medicines specifically in Indian, Chinese, Thai, Korean, Japanese systems of medicine for the treatment of various life threatening diseases such as syphilis, typhoid, cancer, jaundice and hypertension. The powder/paste form and the various extracts of root, stem and leaves are reported to be used as medicine for the treatment of asthma, pyreticosis, cataract, malaria, and diseases of blood, skin and lung (Shrivastava and Patel 2007).

As a traditional medicine, *S. dulcis* has been used for diabetes in India and hypertension in Taiwan. The plant contains various kinds of biochemical compound such as, phenols, saponins, tannins, amino acids, flavonoids, terpenoids and catechnolamines. Various parts of this plant has as an excellent medicinal uses, such as analgesic and anti-inflammatory activity, neurotropic activity, antiviral activity, antimalarial activity, anticancer activity and antidiabetic activity. In Brazil, various parts of the plant are used for abortions, bronchitis, cardiopulmonary disorders, coughs, diabetes, earache, excessive phlegm, eye problems, fever, gastric, disorders, haemorrhoids, hypertension, hyperglycaemia, insect bites, jaundice, liver disorders, malaria, menstrual disorders, pain, upper respiratory disorders, skin problems, worms and wound (Murti et al. 2012).

Leucas lavandulaefolia(Labiatae) commonly known as *'gumo'* is a well-known plant used in the Indian system of medicine. Various parts of this plant have been used in traditional medicine. The plant include phytochemicals are acacetin, chrysoeriol, linifoliside, linifoliol, chrysoeriol-6'' (OAc)-4'-β-glucoside, lupeol and taraxerone. The various in-vivo study of L. lavandulaefolia reported to have hepatoprotective, hypoglycemic, antipyretic, antidiarrhoel, antitussive, wound healing and psychopharmacological, antimicrobial properties (Makhija et al. 2012).

Artocarpus heterophyllus Lam. (Moraceae) or Jackfruit leavesare antishyphillic, anthelmintic, antiulcer, anticarcinogenic, adsorbent, antibacterial, anti-inflammatory and lactogogue. They have been used for years to treat skin problems, fever, boils, wounds, ulcer, diabetes, asthma, wound healing, ring worm infestation, gallstones abscesses, ear ache, anaemia, dermatitis, cough, diarrhoea, fever, sedative, digestive etc. The leaves showed to possesses potential wound healing activity on ex-vivo porcine skin wound healing model which may be due to its phenolic content (flavonoids), triterpenoids constituents especially ursolic acid (Baliga et al. 2011; Periyanayagam and Karthikeyan 2013).

Banana leaves (*Musa paradisiaca*) are packed with plant-based compounds called polyphenols especially epigallocatechin gallate, or EGCG. Polyphenols are natural antioxidants found in many plant-based foods. The plant is reported to have antiulcerogenic, antilithiatic, antimicrobial, analgesic, antihypertensive, antidiarrheal, antiallergic, antioxidant, diuretic, hypolipidemic, hypoglycaemic, hair growth promoting, haemostatic, muscle relaxant, mutagenic, wound healing and vasodilatory activities (Barua and Das 2013).

Methods and materials

The method of preparation of the fermented beverage from rice by the diverse tribes is similar. The difference lies in the variety of rice and medicinal plants that are available in the locality. The processes basically involves two steps – first, the starter culture preparation, and second the brewing of the beverage using the starter culture and boiled rice in smoked earthen pots. The brewing method of beverage production is a healthier option as compared to the distillation method produced by some tribes in other parts of north eastern states.

2a. Starter culture preparation.

Locally available rice, approximately 100g is washed and mixed with locally available medicinal plants and about 8 to 10 red chillies. The method of preparation by the different tribes is the same. The difference lies in the incorporation of locally available medicinal plants. In case of the Garo tribes, the mixture of available rice, red chillies and plant material (*Plumbago zeylanica* or *Thelypteris Clarke*; Fig 3) are pounded and the powder so obtained is mixed with a little inoculum of approximately 7- 10 g of old starter culture and kneaded with water into dough like ball. The balls are flattened and sun dried by placing them within clean dry straw in traditional bamboo baskets called *dokee dona* for at least five to seven days (Fig 4). The Hajong tribes use *Clorodendrum species* or *Leucas lavandulifolia* and *Scopariadulcis L*. along with jack fruit and banana leaves (Fig 5). They prefer to make their starter cake balls first and then coat them with the powdered inoculum before sun drying them the next day (Fig 6). Nevertheless, the starter culture preparation is a definitive model of traditional back-slopping. Once the starter cakes are dried, they are stored and preserved in dried bottle gourds (*Lagenaria siceraraia standl*) in the kitchen near the fire place and used for the beverage preparation whenever needed. (Fig 7)

2b. Method of fermenting rice beverage.

In preparation of rice beverage locally available rice are used. Similar method of brewing is followed by the various tribes. The difference lies in the variety of ingredients used. The Garos use sticky rice variety called *menil*. Unpolished red variety of *menil* or the polished white variety is used. The Hajons and Bodo use yellow boiled rice variety called *mirong*. Each type gives its own characteristic trait to the product with the beverage made from the red variety being sweeter and more appealing. Sometimes the rice is also roasted to impart its unique smoky flavour to the final product. Earthen pots are used for

fermentation of rice. It is very crucial that the pots and bamboo sieves called *Janti* are washed properly with clean water and sun dried completely. The pots and the sieves are then kept over the fire place for further drying and smoking for 5-7 days. These pots are then ready to be used for brewing (Fig 8). The bamboo sieve is placed at the centre of the pot and its open end is covered with banana leaf. Rice is washed and cooked by boiling. The boiled rice is cooled indoors on a bamboo mat. The cooled rice is mixed well with *wanti*, the dried starter culture. About 10g of starter is sufficient to caused fermentation of 2 kg of boiled rice. The rice–*wanti* mixture is then packed around a bamboo sieve placed inside an earthen pot called *dika*. Finally, the mouth of the earthen pot is covered tightly with banana leaves or large ficus leaves and left for fermentation to take place at room temperature mostly near the fire place. During the summers, it usually takes a week for the rice to ferment and produce the beverage while during the winters it takes about a month. During fermentation, a mild fruity sweet aroma is given off within first two to three days followed by the characteristic strong fruity pungent odour after 7 to 10 days of fermentation. This characteristic odour attracts the fruit fly, the Drosophila sps. The appearance of maggot of these flies can be noticed in the earthen pots. The rice beverage is ready for consumption usually after a week's fermentation but it usually left to mature in the earthen pot. The drink whenever desired is extracted by using dried bottle gourd shells (*Lagenaria siceraria Standl*.) called *pong*. A hole is made at the bulb shaped ventral portion of the dried mature fruit into which the beverage gets collected when the pong is inserted into it (Fig 9). The beverage can be kept for about a month in the earthen pots after which it is usually transferred into clean bottles and interestingly can be even stored up to four to five years. The beverage can be consumed directly or by diluting it with water. The undiluted rice beverage is called *bitchi* and the beverage consumed by diluting in water is called *chubok*.

Conclusion

Traditionally brewed rice beverage is consumed on a regular basis daily by the various ethnic tribes of West Garo Hills, Meghalaya. Minimum consumption is considered good for health and believed to acts as a remedy for various ailments due to the incorporation of the indigenous medicinal plant parts in the starter culture and thus the beverage is believed to possess therapeutic properties. However, these products are prepared at house-holds only in remote villages where the ethnic tribal population is predominant without much consideration to hygiene. So far no scientific documentation is available on the microbial or even nutritional aspects of the indigenous beverages in this part of Meghalaya. Hence research on this native beverage is an absolute requisite which can prognosticate many general and specific benefits upon consumption of this beverage. Studies on the herbal and medicinal plant parts used may reveal and prove some other important medicinal properties and beneficial effects of the traditional beverages. Systematic and scientific approach to the process of fermentation would suggest the best rice variety to be used and can stimulate acceleration of the process, produce high-quality and stable product with increased shelf life. Thus, improved production methods in par with GMP and HACCP (Hazard analysis and critical control point's guidelines) will help to upgrade the present status of the traditional beverage and help to economically and feasibly produce it at reduced production costs in future thereby providing a boost to the rural economy.

Acknowledgments

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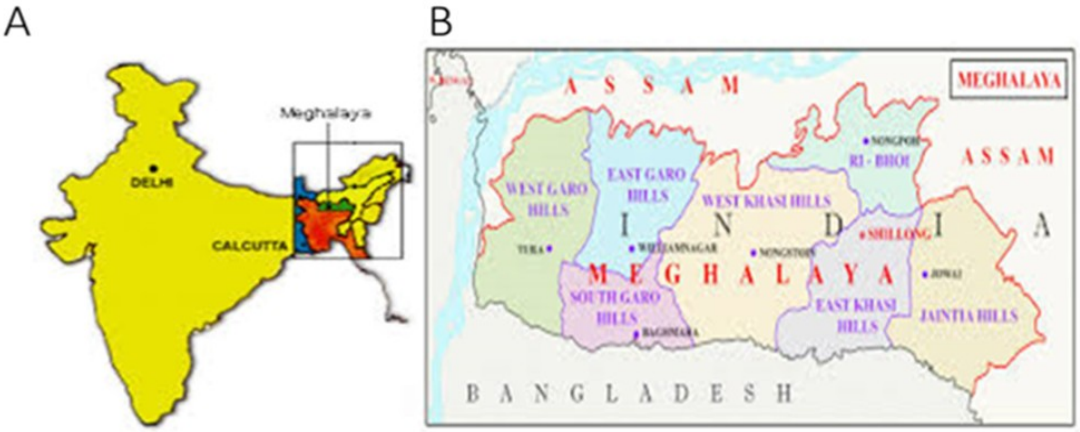


Fig 1: A - Map of India showing the State of Meghalaya. B- Map of Meghalaya showing the location of West Garo Hills

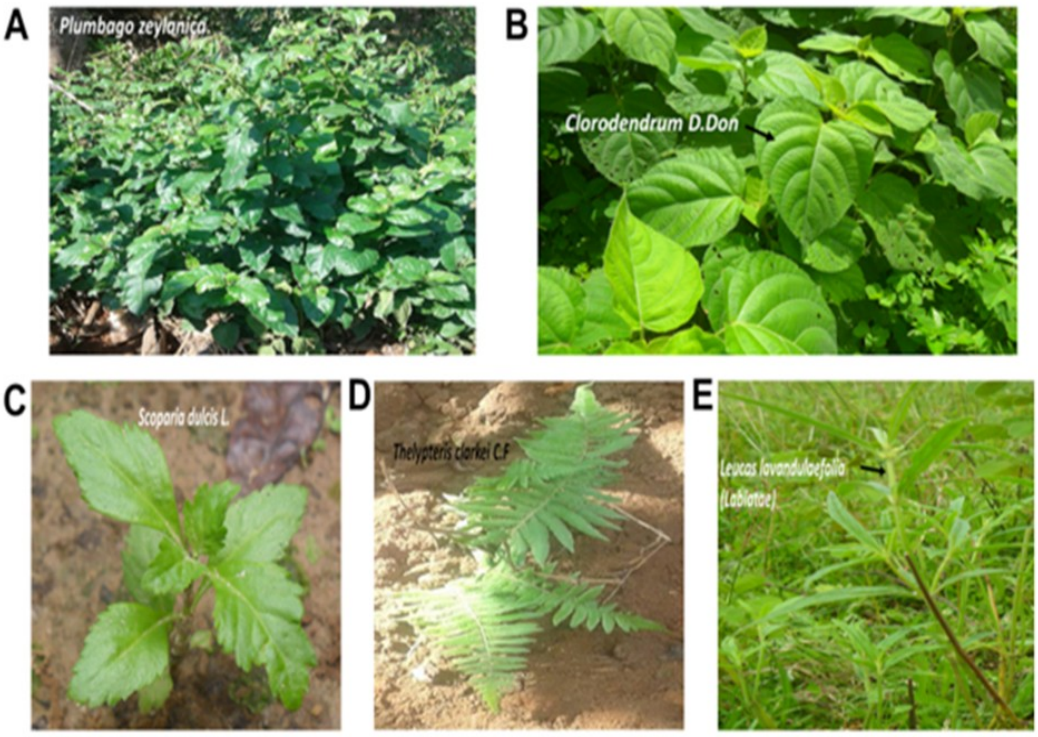


Fig 2: Medicinal plants used by the tribes of West Garo Hills in traditional starter Culture preparation

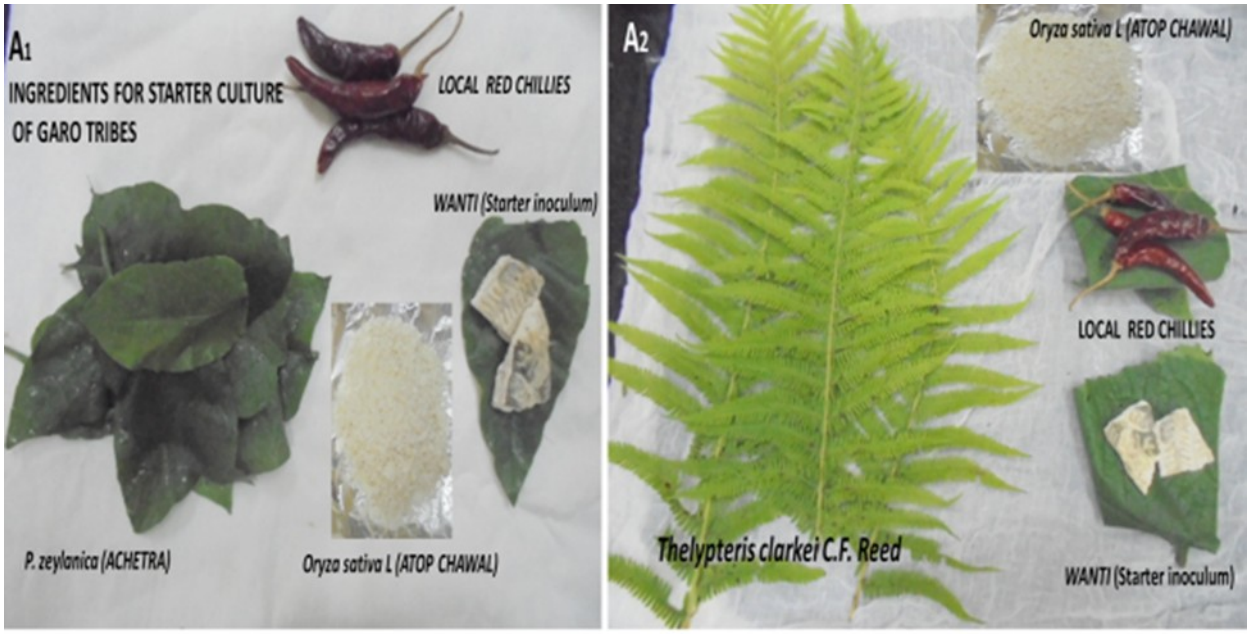


Fig 3: A1 and A2 show the raw ingredients required for starter culture of Garo tribes.

Fig 4: B to I show the methodology of traditional starter culture preparation of the Garo tribes

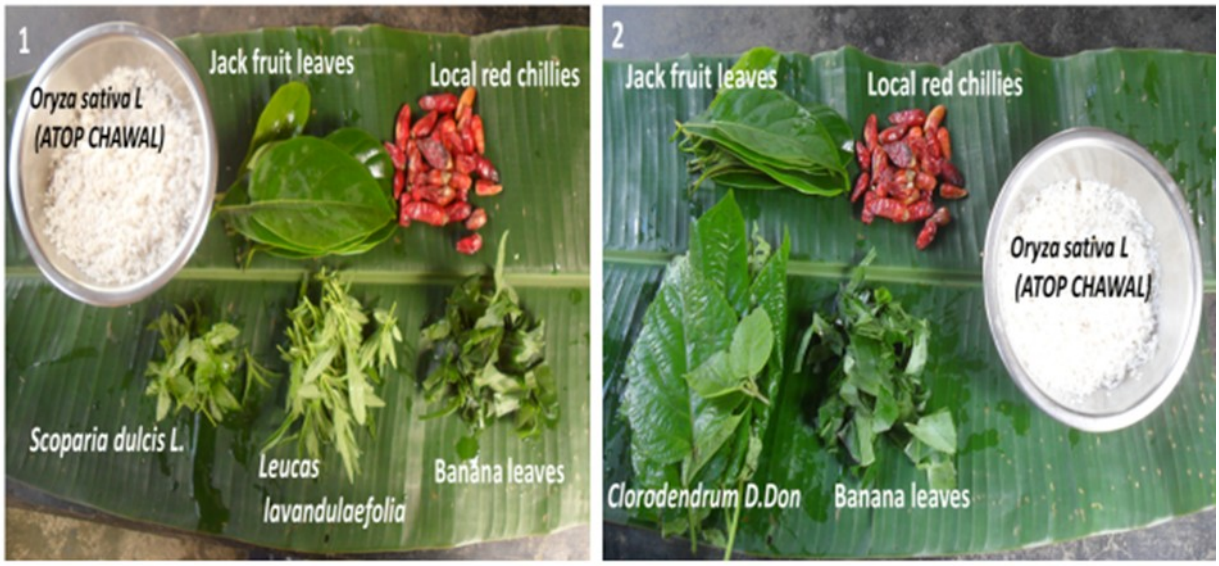
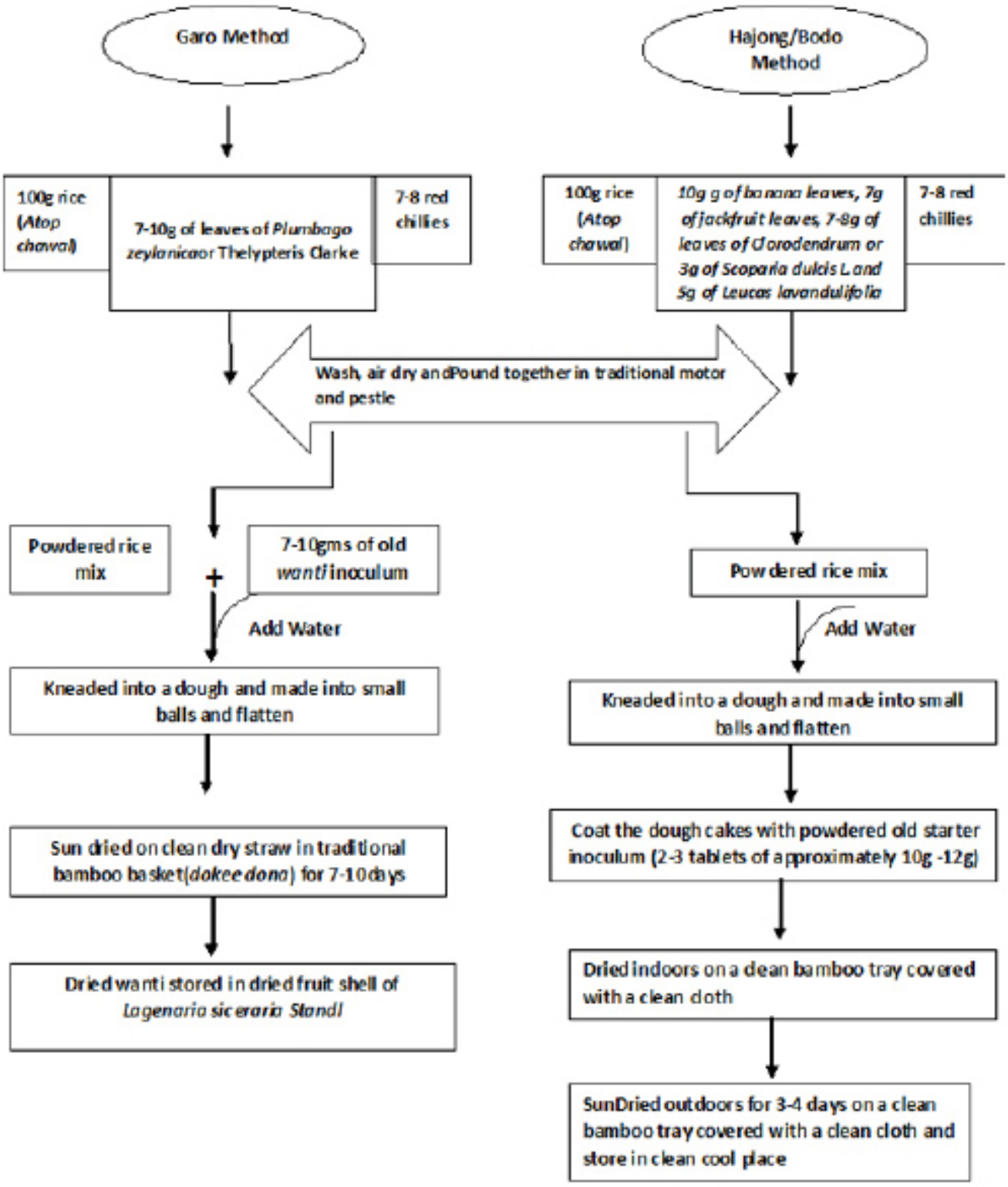


Fig 5: 1 and 2 show the raw ingredients required for starter culture of Hajong and Bodo tribes.

Fig 6: 3 to 15 show the procedure of traditional starter culture preparation of the Hajong and Bodo tribes

Fig 7: Flow chart showing the steps involved in preparation of traditional starter culture (*Wanti*)



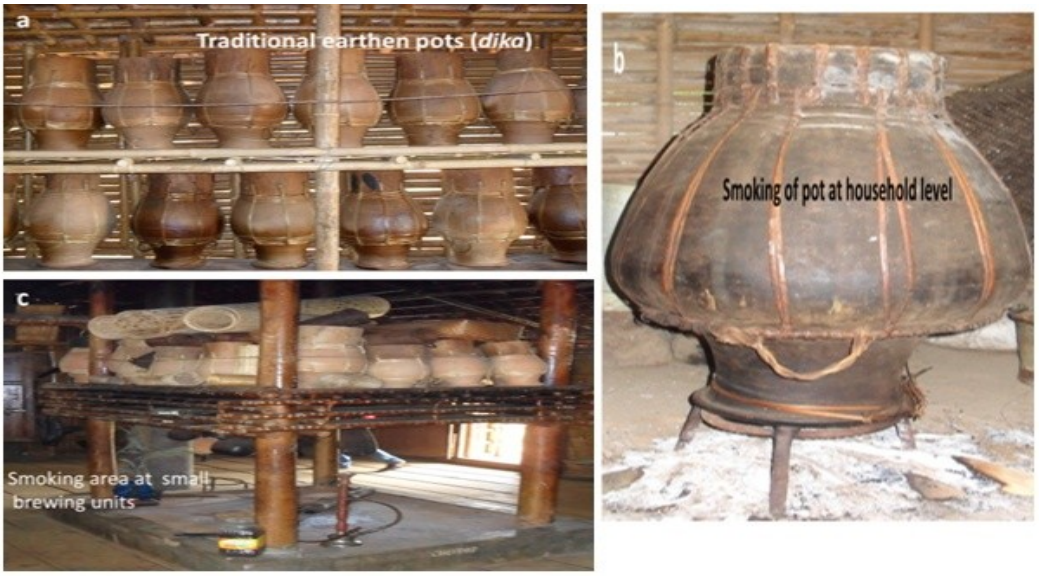


Fig 8: a- traditional earthen pots, b- smoking of pots at house hold level c- smoking of pots at small brewing units

Fig 9:
d to i show the method of preparation of rice wine by the tribes
j to l show the fermented beverage and its traditional mode of consumption

Range extension of snake species from Tura peak, West Garo Hills, Meghalaya, India.

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Abstract:

India is incredibly rich in faunal diversity in the eastern and western Ghats. Meghalaya of North-east India has 56 snake species (ZSI, Shillong). Most of the study of reptiles has been pioneered and persecuted in the early 18th century by the British Naturalists while serving in the then Indian medical service (IMS) or the Indian Forest service (IFS). Many of the snakes were collected and identified during British period and much later by other Indian workers. Most of the herpitofauna work in Meghalaya is done by various surveys conducted at random within the state by the Eastern Regional station of Zoological Survey of India over a span of 33 years. Therefore, in this research survey it was an attempt to inventory the snake species that harbor in the study area. In this paper 4 range extension snake species residing in Tura Reserve Forest are listed and described.

Key words: inventory, snake species, range extensions, Tura peak.

Introduction

India (Fig 1) is incredibly rich in faunal diversity. Among 3150 species of snakes living on earth, 275 species are known from India. So far, 102 species of snakes are recorded from North East India (Ahmed et al, 2009). The fauna of Meghalaya is greatly influenced by Indo-Chinese elements. In Meghalaya alone 56 species of snakes have been recorded by Zoological Survey of India, Shillong. Most of the study of reptiles has been pioneered and persecuted in the early 18th century by the British Naturalists while serving in the then Indian medical service (IMS) or the Indian Forest service (IFS). Their papers were published mostly by the trustees of the British Museum, London. Many of the snakes were collected and identified during British period and much later by other Indian workers. The different species of snakes which were found and identified were mainly contributed by Gray (1831 & 1834-1835), Gunther (1858, 1860, 1864, 1868 & 1875), Jerdon (1870), Schlegel (1837 & 1839), Dumeril and Bibron (1854), Blyth (1854), Kuhl (1820), Dauden (1803), Boulenger (1888, 1890, 1894, 1899); Peters (1864), Schneider (1799 & 1801), Lacepede (1789), Boie (1827), Sclater (1891), Linnaeus (1758), Wall (1907-1908,1910,1921); Nutphand (1971), Shaw (1802), Gmelin (1789), Blanford (1878), Anderson (1879), Slowinski *et al* (200), Cantor (1839), Gray & Hardwicki (1835, Gray 1853), Hallowell (1860), Kramer (1977), Lesson (1831), Reinhardt (1844), Shaw & Nodder (1797), Smith (1937 & 1940), Zhao (1977) and David et al (2002). Gradually serious workers started building up the edifice of the Indian Herpetology brick by brick and in between 1998-2008, 353 new species have been discovered in the Eastern Himalayas, equating to an average of 35 new species every year. Out of 353 new species discovered 16 were reptiles.

Meghalaya is one of the North-Eastern States of India and is a part of the mega biodiversity regions of the world. It has actual forest cover area of 17,146 sq.kms i.e.76.44per cent of the geographical area (FSI, 2017). Garo hills which is a part of Meghalaya is covered with tropical forest which is not only the home of many living creatures but it is convenient place for the snakes to thrive well. Most of the herpitofauna work in Meghalaya is done by various surveys conducted at random within the state by the Eastern Regional station of Zoological Survey of India over a span of 33 years. Other than the above, reptile specimens studied from various institutions in Meghalaya also served as valuable reference. However, thorough research of any snake species in any part of Garo Hills is still lacking. Therefore, in this research survey it was an attempt to inventory the snake species that harbor in the study area. In this paper 4 Range extension snake species residing in Tura Reserve Forest have been listed and described.

Materials and Methods

Study Area

Meghalaya (Fig 2) is one of the North-Eastern States of India and is a part of the mega biodiversity regions of the world. The entire area under Garo Hills was organized as single administrative district in 1873 and Tura as its Headquarter. In October 1979, the district was bifurcated into two districts; West Garo Hills and East Garo Hills. At present it has five districts; East Garo Hills, West Garo Hills, North Garo Hills, South Garo Hills and South-West Garo Hills. There are three important mountain ranges in these districts namely (1) Tura Range (2) Arbela Range and (3) Ranggira Range. The most important physio-geographic feature of Garo Hills are the Tura range and Arbela range which are running parallel in an East-West alignment, extending from Tura to Siju and the Simsang Valley. Tura range is one of the most important ranges in the West Garo Hills as it has 7 mountain peaks. They are Tura Peak, Nokrek Peak, Meminram Peak, Nengminjok Peak, Chitmang Peak, Balpakram Hills and Durabanda.

Tura Peak (Fig 3) of West Garo Hills lies between 25°.00' N and 26°.10'N latitude and 89°.45' E and 92°.45'E longitude. It has green forest cover with an area of 3.94 Km sq. The height of this peak is 873 metres which is located on the eastern part of Tura Town and is about 5.64 Km away.

Tura peak or Tura a.bri (Garo local name) stands next to Nokrek peak (Nokrek Biosphere Reserve) and it is the pride of Tura town. It has many small undulating hills on its side, small streams, rivulets and rivers Rongkhonchi, Gandrakchi, Chitoktak and Didram, two beautiful waterfalls Rengsangrap or Nengsangrap (Fig 4 & 5) and Gangrakdare. It has semi-evergreen tropical forest. It has many rocks and stones, stiff slopes and valleys. At about 250 metres high above there is a place known as Makrekidam (Monkeys Toilet) and about 300-400 metres higher up from Makrekidam there is a place known as Chipu Wari (Snakes Valley) where plenty of different kinds of snakes were found according to what the elderly people have told. Many Biologists have explored Nokrek Peak (Nokrek Biosphere Reserve) and Balpakram hills (Balpakram National Park) as it is rich in both flora and fauna. Though Tura Peak has its own charm and beauty for the people of Tura Town but the reptile fauna of this area is neglected by researchers. Therefore, the main objective was to uncover the reptile fauna that exists in the chosen Tura Peak as my study area.

Fig 1.Map of India Showing the Location of Meghalaya

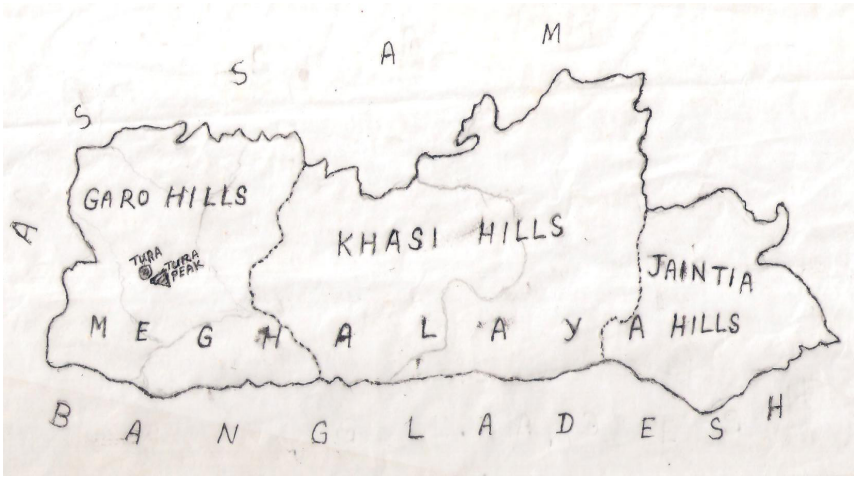

Fig 2. Map of Meghalaya Showing Tura Peak in West Garo Hills.

Fig 3. Tura Peak of West Garo Hills, Meghalaya.

Fig 4. Nengsangrap Falls of Tura Peak Reserve Forest (Dry Season). Fig 5. Nensangrap Falls (Rainy season).

Methods

The data of snakes are collected by Active Searching Methods (ASM), as described by IUCN Reptilian survey methodology and line-transact methods (as per Heyer *et al*, 1993). Six different footpaths leading up to Tura Peak or Tura hill reserve forest was carefully selected for opportunistic chances of encountering the different snakes which are living in the reserve forest. Route (1) Top-Chitoktak via Boldorengre to Tura Peak. Route (2) A.kimbri to Tura Peak. Route (3) Babupara via Rongkhon-chibisik to Tura Peak. Route (4) Nikrang-a.ding to Tura Peak. Route(5) Boldak-a.ding to Tura Peak. Route (6) Sasatgre to Tura Peak. Most of the snake survey was done during the day as well as at night since some of the snakes are active during the day and some of the snakes are active only after dark. We have used search light with an input DC. 7.5 V 500 mA to search the snakes and EOS Cannon camera with EFS 55 mm lens. One snake of each species is photographed and collected from Tura peak for scientific study. Some of the snakes are diurnal where as some are nocturnal and so some snakes come out during the day hours where as some snakes come out in the evening and at night time in search of food and chances are taken to capture and photographed them. Some of the snakes which have been identified as the same species are not captured and they have been left undisturbed in their own microhabitat.

Result and Discussion

We have sighted 25 numbers of snakes from 4 snake species which have been inventoried from Tura Peak(Tura reserve forest) and are range extension species. One species of Python, *Molurus bivittatus* (Kuhl,1820) is from the Family Boidae. Thirteen different snake species are found from Tura Reserve Forest from different locations they are *Psammodynastes pulverulentus* (Boie, 1827); *Rhabdophis himalayanus* (Gunther,1864) and *Sibynophis collaris* (Gray, 1853) from the Family Colubridae. Each of the snakes found from Tura Peak(Tura reserve Forest) are described below:-

Range Extension Species:

1. *Rhabdophis himalayanus* (Gunther, 1864) was uncovered from Tura Peak, West Garo Hills after 176 years. Earlier it was reported from Risa Colony, Tripura Castle road, Motinagar forest, Khasi Hills and from Sonarpur river, Jaintia Hills by Murthy in 1986 which were collected by different people. It is also found in manipur, Nagaland and Eastern Himalayas(Ahmed *et al*,2005).

2. *Sibynophis collaris* (Gray,1853) was found for the first time in Garo Hills, after 160 years. It was uncovered from the forest floor at Top Chitoktak under Tura Peak reserve forest. It has been reported from Khasi Hills, Shillong, Kenche's Trace, Malki Forest, Forest colony, etc. and from Jaintia Hills, Jowai by Murthy in 1986. It is found from Himalayas, Shimla to the Northeast (Mishmi Hills and Patkai Hills).

3. *Psammodynastes pulverulentus* (Boie, 1827) was found for the first time at A.kimbri near the stream under Tura Reserve Forest after 186 years. Murthy had reported in 1986 from Motinagar forest, Tripura castle road, Old Barapani road, Lawsohtun, Shillong, B.S.I. Compound from Khasi hills, Meghalaya. It is also found in Assam, Arunachal Pradesh, Mizoram, Northern India and Orissa (Ahmed *et al*, 2005).

4. *Python molurus bivittatus* (Kuhl, 1820) was rediscovered from Tura Peak after 193 years. It was earlier recorded from Burnihat, East Khasi Hills, Meghalaya (Murthy, 1986) and these species is mainly restricted in the Northeastern states and as far west as Uttaranchal, Dehra Dun (Whittaker & Captain, 2004). It was recorded for the first time in West Garo Hills, Meghalaya.

Description Of Range Extension Species:

(1) *Rhabdophis himalayanus* (Gunther, 1864) Wamikglo (Garo):

Himalayan Keelback (Fig 6 & 7) was first sighted from Upper Chitoktak (N 25°31'120'' & E 090°14'22.9'') on 27-4-13 at 5.07 PM near small dried stream just below a huge rock. It was captured, photographed and its measurement taken 110 cm (1100 mm) SVL in length. The characters are observed and its species was confirmed. The head is broader than the neck. It has large round pupil. The scales are keeled. The back of head has bold, broad with orange collar. Back of collar bordered with dark green just like the head. It has reddish orange checks on the fore body. The upper body is dull grey dotted with black and a series of small yellow spots or short cross-lines on each side of hind body. Lip scales are white which are separated by black lines. The underside is steel grey speckled with black. Total encountered five numbers and found to be com-

mon in the study area.

Fig 6 & 7. *Rhabdophis himalayanus* Wamikglo (Garo)

(2) *Psammodynastes pulverulentus* (Boie, 1827) Rete (Garo):

Common Mock Viper (Fig 8) is commonly found in Tura peak, forest edges, near human habitation, mainly near the shrubs and among grasses. It was first sighted on 13-5-13 at 8.34 AM from Upper Chandmari (N 25°31'24.3'' & E 090°14'08.5''). It was an adult which was captured, photographed and its length was measured 45 inch (113.8 cm). Species identity was confirmed from the characters. Head is broader than the neck. The body is dark chocolate brown with small black and white streaks which are paired. The trunk is huge and broad compared to the head and tail. The underside of the head and neck are dark brown, underside of the thorax region is yellow with small brown spots. On the side of lower jaw there are four small white patches. There are yellow W-shaped patterns on either underside of the thorax and extending to the mid-abdomen. The underside abdomen has glossy with pinkish brown mixed with white spots. The head has 'Y' shaped darker mark and two elongated marks on sides. Three juveniles were sighted from different locations; Upper Chitoktak, upper Chandmari and Upper Babupara in the month of June-July measuring 20cm, 23cm and 25cm respectively.

(3). *Sibynophis collaris* (Gray, 1853) Sko-Gisim (Garo)

It was first sighted on 19-10-13 on 1.44 PM from Top Chitoktak on the forest footpath. It was a very young juvenile. It was collected for photography and preservation. It was identified after careful observation of its characters. It has a slender body which has smooth scales. Head is slightly broader than the neck; eye has round pupil. Tail is long which gradually tapers towards the end (Whitaker & Captain, 2004). We have encountered only two snakes of this same species (Fig 9).

(4) *Python molurus bivittatus* (Kuhl,1820) Chipu Jada (Garo):

Burmese Python (Fig 10) was caught by the local people from Tura Peak reserve forest (N 25°31.34'8'' & E 90°14.29'5'') at an altitude 2490 ft on 16-10-12 at 4.07 PM. According to the woodcutters it was foraging in the deep jungle which was caught alive for fun-food. It measured 1140 mm (84 in). It was a sub-adult which could have grown bigger and longer. Species identity was confirmed by observing its characters. It has a thick body and smooth scales. Head is broader than the neck and its eyes has vertical pupil. It has heat sensitive pit at the tip of snout. The head has large scales of different shapes and sizes. The body has yellow asymmetrical marking on dark brown body which has black-edged blotches. On the head there is tip of arrow-head mark which is well distinct. Two dark streaks are present on the side of head; one below and the other through the eyes. The underside of the body is light yellow. We have encountered only one python.

Discussions

We have found one *Python molurus bivittatus* (Kuhl, 1820) from Tura Peak. It is recorded for the first time in West Garo Hills, Meghalaya. Though python is found in Garo Hills, it has not yet been reported by any researcher. It had been captured by local people from Study area which we have managed to photographed. *Psammodynastes pulverulentus* (Boie, 1827) is common in the study area. It is found beside the rocks, shrubs and near the streams. *Rhabdophis himalayanus* (Gunther, 1864) and *Sibynophis collaris* (Gray, 1853) are rare as they are difficult to find them. There are various different types of snake in

Fig 8.*Psammodynastes pulverulentus* adult. Chipu Rite(Garo).

Fig 9. *Sibynophis collaris* juvenile.

Tura reserve forest which can be explored for further research when suitable conditions prevail. Many of the snakes which were encountered are generally found on the forest tracts, forest edges and near human dwellings. Since Snakes are considered enemies of human whether they are venomous or non-venomous they are not spared whenever encountered. Many snakes are crashed on the roads by running vehicles and motorbikes accidentally. Snakes are not considered important by local people as it is a creepy creature. Although it plays an important role in pharmaceutical laboratory and important food chain in ecosystem, snakes are mercilessly killed for no reason mainly due to irrational fear. If we have to conserve these creatures, awareness among different sections of people have to be made.

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Fig 10. *Python molurus* Chipu Jada (Garo)

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Comparative Raman Spectroscopic Study of 5O.14 compound at room temperature

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Abstract: Studies using Raman spectroscopy for a higher homologue 5O.m (m=14) liquid crystalline compound is presented in this paper. The paper reports the comparative studies of experimental and theoretical Raman spectra at room temperature for this sample. DFT methods using standard functional B3LYP with the 6-31G basis set was used to perform the theoretical Raman calculations. The simulated Raman spectra results were found to be in excellent agreement with the spectral pattern obtained using the experimental study of the sample. From the study it was observed that the compound has significant Raman active modes which reveal detailed information on the different segments of the compound which can be used to explain many of its observed properties.

Introduction:

In the past few decades the liquid crystals have played a very important role in the device applications due to the unique mesogenic behaviour. This mesogenic nature makes it an extraordinary material in the fields of optics, electro-optics, thermal devices, sensors and switching devices. The application of these liquid crystals has been so popular that mobiles, TVs, monitors and smaller electronic devices have displays (LCds) which are made of liquid crystals. To explore and exploitmore features of the liquid crystalline phase, we have to understand more precisely the structure – property relationship as well as the correlation of the mesogenic phases to the constituents at the molecular level[1, 2].

Generally, the property and phase behaviour of the LC compounds depend on the shape and size of the molecule and also the interactions within the molecule which influence the behaviour of the compounds. In the LC phase the intra and inter molecular interaction also influence the molecular property of the compound. Therefore, vibrational spectroscopic studies have a great potential to understand the molecular dynamics of the compound. [1-5]. The Ramananalysis based on molecular behaviour and DFT computational techniques helps to understand these dynamical behaviour of the compounds.

In the last two decades, the computational methods applied in the study of LC molecules have evolved significantly. During the past few years, several computational methods has been used with different basis sets. Methods based on semi-empirical analysis and HartreeFock simulations have been extensively used. However, the best results have so far been obtained with density functional theory (DFT) using the B3LYP function with the standard basis set of 6-31G. This combination of functions and basis sets give a sufficiently good approximation and replicate most of the experimental results with a suitable scaling factor.

In the present study we investigate the 5O.14 liquid crystalline compound. The compound was investigated earlier and was found to be interdigitated as well as partially bent-like in nature [7-9]. The main focus of our study is to simulate and interpret the theoretical results of this compound.

Experimental and computational details: -

The samples 50.14wassynthesisedas per the procedure reported elsewhere [10]. The phase transition temperatures of these two compounds and are shown in Table.1

Table: 1

5O.14	Temperature
I-N	71.5 ^{0} C
N-S_A	69.3^0 C
S_A-S_B	51.7^0 C
S_B-C	43^0 C

Computational method: All quantum chemical density functional calculations were carried out using Gaussian 09 program package. The method we adopted for this calculation was hybrid density functionals theory using the Becke three hybrid density functionals for exchange part and the Lee, Yang and Parr hybrid functional for correlation part (B3LYP) combined with the standard basis set 6-31G(d,p). The Gaussian 09 package plots the simulated Raman activity.

Results and discussions: -

The 5O.m series of liquid crystals exhibits interesting phase sequences, N-Sc (m=2), N-S_A-S_C-S_F-S_G (m=5), N-S_A-S_C-S_B-S_F-S_G, (m=6) and N-S_A-S_B or N-S_A for the higher homologues [13]. In this study, our work is focused on a higher homologue 5O.m (m=14). This compound is significant for investigation as it has an unsymmetrical alkyl chain length distribution of 5 alkyl groups at one end and 14 at the other. [7, 15].

To understand the molecular conformation more accurately,DTF studies were conducted which givesa deeper insight in to this liquid crystalline compound. This optimization of the compounds were carried out in the framework using B3LYP and 6-31G(d,p) basis set. For successful application we have also used this B3LYP functionls with stabdared basis set 6-31G (d,p) in both compounds.

Frequency assignment discussion:

A careful explanation of the figure 1,2(a,b)reveals an anomalous behaviour of the spectral features for all and Raman bands.

At the range 1800 cm^{-1} to 1600 cm^{-1} three distinct Raman spectra were observed. This region contains C=N and benzene ring. The observed band at frequency regions 1627 $cm^{-1}$is mainly due to C=N bond. The C=N bending modes was stretching and the intensity were strong in this compound. The band at 1598 cm^{-1} and 1580 cm^{-1} were mainly due to quadrant stretching mode of the aromatic ring.The band assignments for the relevant bands under study for this compound are presented in table 2. In C-O-C ether groups, two peaks were observed in both compounds. For the compound 5O.14, the frequency at 1210 cm^{-1} and 1168 cm^{-1} two distinct Raman peaks appeared. The mode of this vibration at 1210 cm^{-1} was stretching and the intensity was strong. This stretching mode was related to C-O-C in vinyl ethers. At position of 1168 cm^{-1} the intensity was strong and spectrum arises due to C-O-C aliphatic ethers and also aromatic CH in plane bending mode. From the figure 1,2 (a,b) , it was clearly observed that,both the theoretical and experimental Raman Spectra at room temperature with good agreement for the compound.

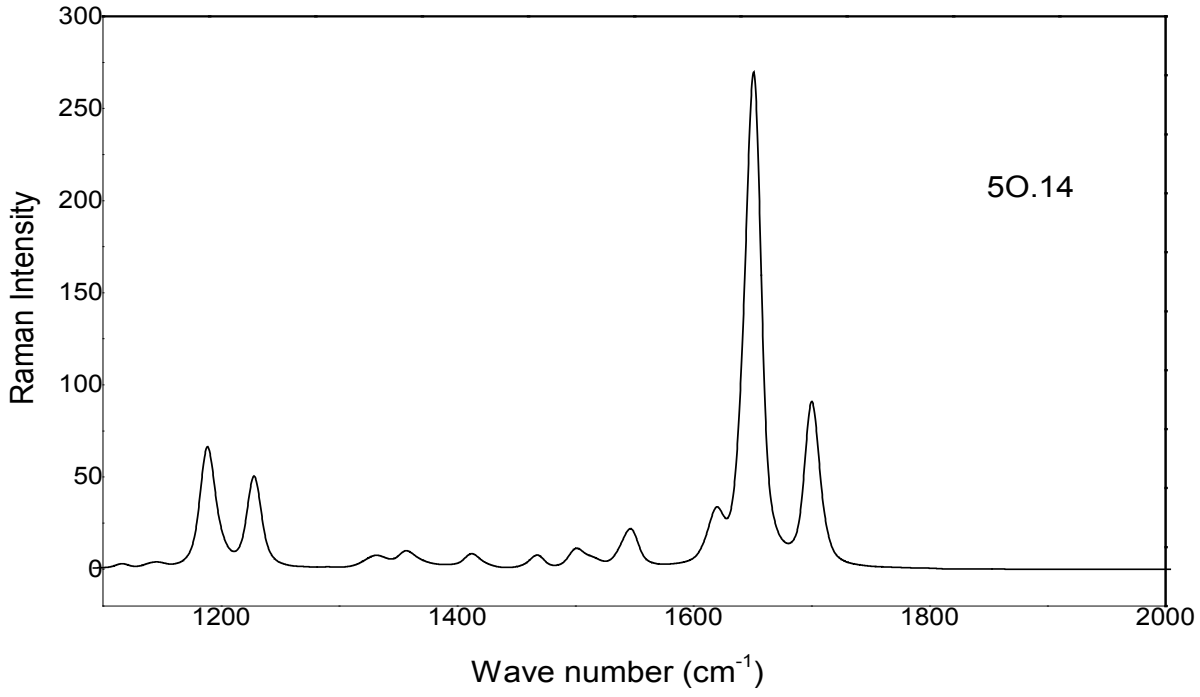
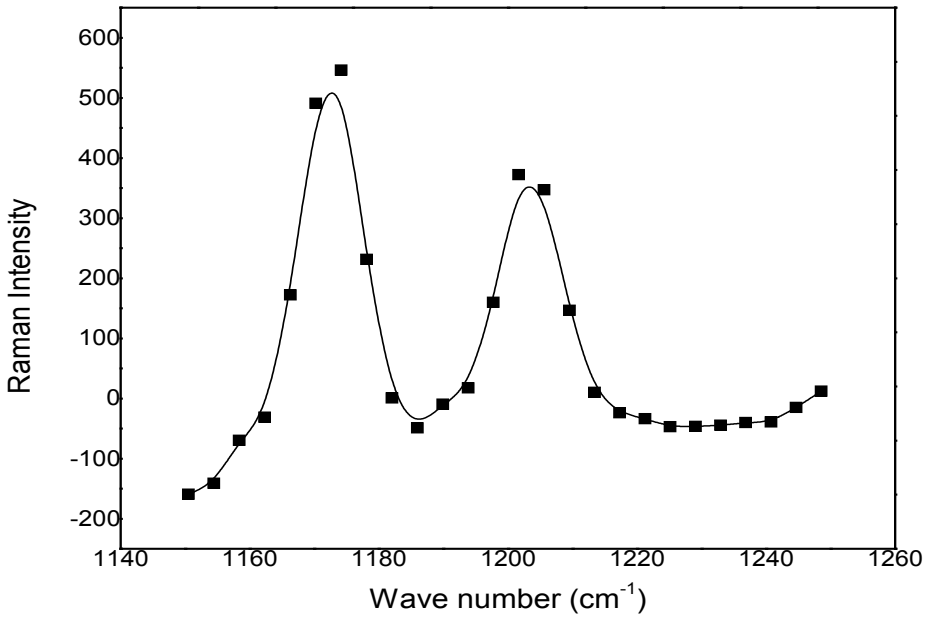
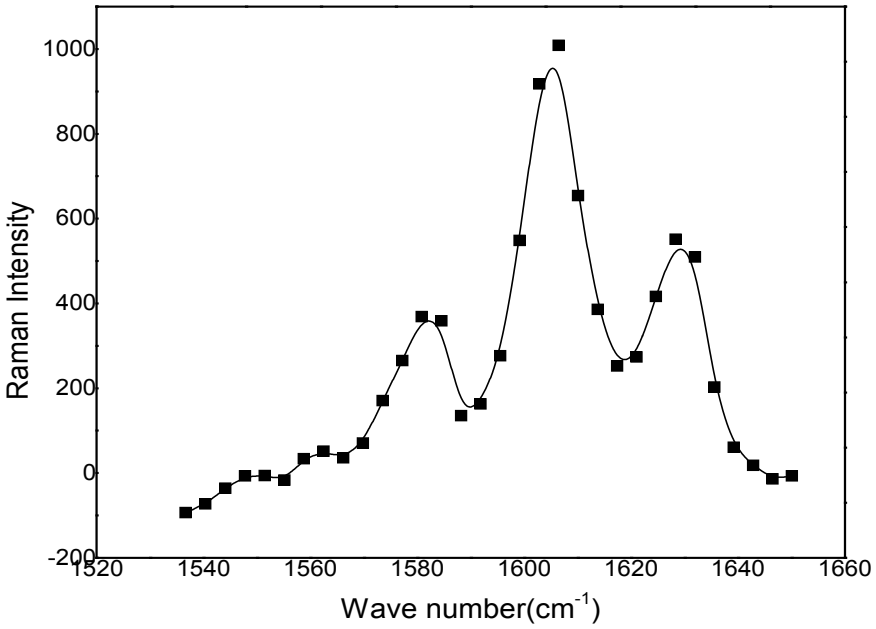


Figure 1: Theoretical Raman spectra of 5O.14 compound



(a)



(b)

Figure 2(a,b): Experimental Raman spectra of 5O.14 compound

Table 2. Band Assignment for liquid crystalline compound 5.O14

Serial No.	5O.14 (Raman) (cm^{-1})	Assignment
1	1627	C=N stretching mode (strong)
2	1598, 1580	Quadrant stretching mode of the aromatic ring (Medium, weak , multiple bands)
3	1210 ,1168	C-O anti-symmetric stretching mode (Two bands or multiple bands
4	1168	Aromatic C-H in plane bending mode

Conclusion: - The quantum computational analysis of 5O.14 compound was performed using density functional theoretical approach. The calculations were performed using the hybrid density functionals theory using the Becke three hybrid density functionals for exchange part and the Lee, Yang and Parr hybrid functional for correlation part (B3LYP) combined with the standard basis set 6-31G (d,p). The simulated and experimental Raman spectra show good results with proper agreement at room temperature.

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REVIEW PAPER

Applications of DNA barcoding for identification of horticultural plants

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Abstract

DNA barcoding is a new emerging technology to provide rapid, accurate and automated species identifications using short orthologous DNA sequences in the form of four standard barcodes namely *rbcL, matK, trnH-psbA* and ITS, which is based on extracting a DNA sequence from a tiny tissue sample of any organism. Although DNA barcoding technology has been in use for less than a decade, it has progressed markedly in terms of the number of sequences generated as barcodes as well as its applications. Hence, it has been considered as the centre of focus in exploring and conserving the biodiversity all over the world. The increasing globalisation of medicinal and minor crops for human benefits implies a major risk for species substitution or uncontrolled admixture of manufactured plant products with severe consequences for the health of consumers. Therefore it is necessary to provide a reliable and single identification database containing all the information about the quality and hidden potential of the unexplored and underutilised authentic horticultural plant materials of North East India using DNA barcoding for the effective utilisation and conservation. This paper reviews the latest information on generating, applying and analyzing the DNA barcodes used for horticultural plants.

***Key Words*: DNA barcoding, *rbcL, matK, trnH-psbA* and ITS**

Introduction

The North-Eastern Region of India has a variable range of altitudinal and topographic variations which govern the occurrence and distribution of a vast biodiversity in horticultural plants. The flora of this region grows according to variation in climatic zones and has been designated to be a biodiversity 'hotspot'. The agroclimatic conditions of this region enrich and accomplice with wide varieties of wild and underutilised plant species such as wild variety of brinjal and potatoes (vegetables); pineapple, Aonla, strawberry, jackfruit, mango, litchi, banana, kiwi fruit, "Sohiong" and carambola (fruit crops); coconut, arecanut, cashewnut (plantation crops); yam and tapioca (tuber crops) & king chilli, tamarind, ginger and pepper (spices). The region has different varieties of Orchids which are also medicinally very important besides their ornamental values and it is also a repository of various *Citrus* species such as *Citrus indica, C. macroptera*, *C. latipes, C. megaloxycarpa* including other wild citrus species.

People from this region have profound traditional knowledge in the use of herbs as their local and wild vegetables & medicines. Many important plants including horticultural plants are distributed with high potential; but, many plant species are depleting from their natural habitats whereas some are 'underutilised and unexplored'. The main causes of depletion of these important plants are due to high pressure of exploitation through shifting cultivation, land erosion, industrialisation, trade and commerce, urbanisation, etc.

There is a need to explore and identify the 'underutilised and unexplored crops' used by the local communities of this region, having great potential or advantages especially in medicine and for commercial purposes but are not yet commercially exploited. Heavy dependence on just a handful of crops is risky. Hence, exploring these 'underutilised and unexplored crops' using DNA barcoding by identifying and converting into economically useful plants for future reduces this risk as an alternative source of income for the local people in this region.

DNA barcoding is a novel system which uses short and standardized gene regions of DNA (400–800 bp) as internal species tags that involve data collection, storage, analysis, visualization and proper management to use a fragment of DNA sequence for exploration and identification of any species. In DNA barcoding, a complete data set can be obtained from a single specimen irrespective to morphological or life stage characters. This technique was proposed by Paul Hebert (2003) from the Canadian Univer-

sity of Guelph who used a sequence of the COI mitochondrial gene, coding for cytochrome oxidase 1, as a "molecular signature" to identify Lepidoptera. This was soon followed by studies that claimed success rate in species e.g., in birds, fish and mosquitoes. The core idea of DNA barcoding is based on the fact that the highly conserved stretches of DNA, either coding or non-coding regions, vary at very minor degree during evolution within the species.

Researchers throughout the world have worked together to establish some of the major barcoding initiatives for future. The primary goal is to develop an efficient DNA barcoding based species identification system which will be universally applicable. The two major international barcoding initiatives are the International Barcode of Life project (iBOL) (http://www.ibol.org/) and Consortium for the Barcode of Life (CBOL)(http://www.barcodeoflife.org/).There are several barcode libraries which are freely accessible such as the BOLD (Barcode of Life Data system) (http://www.barcodinglife.com), Gen Bank (http://www.ncbi.nlm.nih.gov/genbank/), MMDBD (Medicinal Materials DNA Barcode Database) (http://137.189.42.34/mherbsdb/index.php) and GDR (Genome Database for Rosaceae) (http://www.rosaceae.org/) (Bhargava and Sharma, 2013; Techen *et.al*, 2014).

DNA barcoding provides a practical, standardized and species-level identification that have wide applications in biodiversity assessment, life history and ecological studies, forensic analysis, for monitoring water quality, controlling agricultural pests, identifying disease vectors, preserving and sustaining natural resources, food traceability, routine authentication of natural health products, protecting endangered species.

Henceforth, using DNA barcoding technique, the identification and authentication for locals, wild, unexplored and underutilised plants of this North-Eastern region carries a significant work. This will open new avenues for propagation, conservation, hybridisation and evolution of socio-economic development of this backward region.

DNA barcoding in plants

DNA barcoding technique is advantageous, as it can be used even if flowers or fruits are not available for identifying the specific plant species. Therefore, plant DNA barcoding has a huge role in the conservation of plant material and also to monitor the national and international trade in rare species. Many candidate gene regions have been experimented and recommended as possible barcodes for plants but still there is no universal barcode for identification of plant species. The major strength of DNA barcoding is directly related to the data available in the barcode libraries which helps in building a very complete DNA barcoding database. The methodology in this technique must be realistic and accessible for a wide range of practitioners and other multiple users. The following factors are to be considered in selecting a plant DNA barcode (Selvaraj, 2013):

(i) the universal and standard range of PCR condition along with a set of standard PCR primers per gene,

(ii) the range of taxonomic diversity,

(iii) the power of species differentiation, and

(iv) the dry lab analysis and application

The factors mentioned above for selecting a plant DNA barcode serve as a robust barcode marker for the widest range of taxa.

The barcoding primers for plants

The primer designing is the first and foremost important step in initiating the screening of various reported candidate genes towards their suitability in every species. The forward and reverse sequences of a primer should be carefully combined, the PCR technique including the specific annealing temperature has to be standardized and the efficacy should be tested for each gene before proceeding with the DNA barcoding. Sometimes, the reported sequences for any of the candidate genes may not work and under such situation, one has to design their own primers for each gene, after retrieving the respective gene sequences from the public domains such as National Centre for Biotechnology Information (NCBI). For this purpose, the online open access tools such as Primer 3 may be used. These softwares along with all the possible forward and reverse primer combinations provide the annealing temperature for performing the PCR technique (Mathew, 2013).

Potential DNA barcode for plants

The DNA barcodes are important in identification of species because of its universality and specificity on variation. But the plant DNA barcoding studies were initially restricted to the chloroplast genome to understand the variation of its gene sequences of coding (*matK, rbcL, rpoC1* and *psbA-trnH*) and

non-coding (ITS, *psbA-trnH*) (Chen *et.al*, 2005). Cytoplasmic mitochondrial DNA such as mitochondrial cytochrome c oxidase COX1 and chloroplast DNA e.g. Large subunit of ribulose-bisphosphate carboxylase (*rbcL), trnH–psbA* ***intergenic spacer,*** maturase K *(matK),* chloroplast NADH dehydrogenase F *(ndhF),* andadenosine triphosphate β subunit *(atpB)* & nuclear DNA e.g., internal transcribed spacer (ITS), and housekeeping genes such as glyceraldehydes-3-phosphate dehydrogenase (GAPDH) are the suggested sequences to be useful in DNA barcoding. Some of the important DNA markers are described briefly as follows:

matK

The *matK* (a plastid plant gene of chloroplast) codes for maturase like protein, which is involved in Group II intron splicing from RNA transcripts. The size of the gene is about 1550 bp in length, which was located within the intron of the *trnK*. Since *matK* is embedded in the group II intron of the lysine gene *trnK,* it can be easily amplified with a primer set designed from the conserved regions of the genes *trnK*, *rps16* and *psbA*. *matK* has been used as a marker to construct plant phylogenies because of its rapid evolution and the ubiquitous presence in plants. Among the available chloroplast genes, *matK* is one of the most rapidly evolving genes depicted from its high substitution rates, which makes it the ideal barcode candidates which is being used in the studies of molecular systematics and evolution (Selvaraj, 2013).

The *matK* gene has been used effectively in phylogenetic studies for the families Orchidaceae tribe Vandeae (Jarrell and Ciegg, 1995), Zingiberaceae (Sevaraj *et.al*, 2008), Saxifragaceae (Johnson and Soltis, 1994), Polemoniaceae (Steele and Vilgalys, 1994), Poaceae (Liang and Hilu, 1996) and Myrtaceae (Gadek *et.al*, 1996). The efficiency of *matK* in species delineation like DNA barcoding in ethnomedicinal plants (*Rauvolfioideae: Apocynaceae*) from Northeast India have also been tested (Mahadani *et.al*, 2013).

rbcL

Among the other plastid genes, the ribulose-bisphosphate carboxylase gene (*rbcL*) is the best characterized gene sequence. It was determined from 58 species, representing almost all families of Leptosporangiate ferns. It contains only exons, polypeptide with ~475 amino acids. It encodes the large subunit of rubilose-1,5-bisphosphate carboxylase/ oxygenase (RUBISCO). As RUBISCO is a critical photosynthetic enzyme, *rbcL* was the first gene that was sequenced from the plant. But even single amino acid replacements in *rbcL* could result in differences in the CO_2 and O_2 specificity of RUBISCO. The amino acid difference in *rbcL* plays an important role in ecological adaptation. The sequence of *rbcL* has great phylogenetic importance because of its conserved nature although substitutions occur in sites of known functional importance (Selvaraj, 2013; Vijayan and Tsou, 2010).

A contingency analysis was performed to evaluate the rbcL+matK barcode among the major taxonomic groups by comparing the two DNA barcode markers *rbcL* and *matK, rbcL* shows better coverage than *matK* for the native flowering plants and conifers of Welsh flora (de Vere *et.al*, 2014). DNA barcode authentication tool was used to differentiate medicinal *Cassia* species by using PCR amplification of four DNA barcoding markers *matK, rbcL, trnH-psbA* and ITS2 from 64 accessions that belong to 20 species of the genus *Cassia* (Purushothaman *et.al*, 2013).

psbA-trnH intergenic spacer

The *psbA-trnH* intergenic region between tRNA-His and photosystem II D1, contains two parts that differ in their evolutionary conservation, *psbA* 3´UTR, which is responsible for the regulation of gene expression, and *psbA-trnH*, which is a non-transcribed intergenic spacer that has no function because of its high variability across angiosperms. Various studies revealed that the end spacer of the intergenic spacer *psbA-trnH* nearest to *psbA* was highly conserved and showed a large inversion at the end nearest to *trnH*, which appears to be more variable. The structure of *psbA-trnH* has a small spacer region with a length of about 200–500 bp especially in angiosperm and gymnosperm species. However, the high nucleotide variation has made it difficult to identify conserved regions among the highly diverged taxonomic groups but short regions (6-30 bp) were conserved across angiosperms (Selvaraj, 2013).

The *psbA* gene encodes the D1 reaction center protein of photosystem II and its expression depends on light intensity, the plant developmental stage and the physiological state of the plant. This gene accumulates to high levels in chloroplasts. The *trnH-psbA* region shows several other traits such as suspect edubiquity in plants, high interspecific sequence divergence and universal flanking primers that allow easy amplification and sequencing. It also contains mononucleotide repeats which are difficult for se-

quence accuracy and insertion events.

ITS

The Internal Transcribed Spacer (ITS) region belonging to the nuclear genome is a non-functional RNA sequence located between the 18S and 25S rRNA coding regions. The ITS1 is present between 18S and 5.8S rRNA, while ITS2 is between 5.8S and 25S rRNA. The ITS was a transcriptional unit situated between the structural ribosomal RNA during rRNA maturation leaving the ITS spacers excised. The ITS region of the nuclear DNA (nrDNA) occurs as tandem repeats at multiple chromosomal loci. The high copy number of the ITS region promotes detection, amplification, cloning and sequencing of nr DNA and the PCR efficiency of the ITS region is high when compared to barcode candidates. Therefore, it can be further subjected to restriction digestion, which generates distinctive diagnostic bands that can be used to effectively differentiate and identify plants at their species level (Selvaraj, 2013).

The identification of native Dendrobium species in Thailand by PCR-RFLP of rDNA-ITS and chloroplast DNA were studied (Surin *et.al*, 2014). A new phylogenetic analysis on the relationships in the *Calanthe alliance* was performed based on nucleotide sequences of the nuclear internal transcribed spacer (nu ITS) and chloroplast DNA (cpDNA) genes of 88 taxa representing the major clades of the *C. alliance* (Orchidaceae) in China (Zhai *et.al*, 2014).

The trnH–psbA region is found to be useful in identifying many plants and herbal species but it was unable to differentiate *Citrus chachiensis* hort. (Rutaceae) from *C. grandis* (L.) Osbeck and other *Citrus* species (Su *et.al*, 2010). One disadvantage of the trnH– psbA region is that it does not generate bidirectional unambiguous sequences (CBOL, 2009).

DNA barcoding development in Horticultural Plants

DNA barcoding is an emerging field in identification of horticultural plants. Many works have been performed and are in progress on various horticultural plants, but there is an urgent need to use this technique to standardise the candidate gene and primer for identification and authentication of local and wild varieties of unexplored plants found in Northeastern region of India for the economic development of this region.

Table1: Different DNA barcodes (*rbcL, matK, trnH-psbA* and ITS) used for the identification of horticultural plants

Sl.no.	Analysed Material	DNA Region Used	References
1	*Acacia* species	ITS2	Yao *et al.,* 2010
2	*Aloe vera*	matK	Mahadani and Ghosh, 2013
3	*Allium schoenoprasum*	rbcL**,** matK, trnH-psbA	Anvarkhah *et al.,* 2013
4	*Allium ampeloprasumpersicum*	rbcL, matK, trnH-psbA	Anvarkhah *et al.,* 2013
5	*Allium cepa*	rbcL**,** trnH-psbA	Anvarkhah *et al.,* 2013
6	*Artemisia* species	ITS2	Yao *et al.,* 2010
7	*Artocarpus* species	ITS	Zerega *et al.,* 2010
8	*Astragalus* species	ITS2	Yao *et al.,* 2010
9	*Aspalathus* species	ITS2	Yao *et al.,* 2010
10	*Begonia* species	ITS2	Yao *et al.,* 2010
11	*Capsicum* species	matK, trnH-psbA	Jarret, 2008
12	*Centaurea* species	ITS2	Yao *et al.,* 2010
13	*Cheilanthes wrightii*	rbcL	Pryer *et al.,* 2010
14	*Citrus* species	ITS	Wang *et al.,* 2012
15	*Cinnamomum* spp.	*trnL–trnF* chloroplast DNA	Kojoma *et al.,* 2002
16	*Cliffortia* species	ITS2	Yao *et al.,* 2010

17	*Compsoneura* species	rbcL, matK, trnH-psbA	Newmaster *et al.,*2008
18	*Conocephalum* species	rbcL	Miwa *et al.,* 2009
19	*Dendrobium* species	psbA-trnH	Yao *et al.*, 2009
20	*Dendrobium* species	ITS	Takamia *et al.,* 2011; Chiang *et al.,* 2012
21	*Dendrobium* species	matK, rbcL	Asahina *et al.,* 2010
22	*Draba* species	ITS2	Yao *et al.,* 2010
23	*Ficus* species	ITS2	Yao *et al.,* 2010
24	*Fragaria* species	*nuITS, psb*A-*trn*H	Yu *et al.,* 2011
25	*Hibiscus rosa-sinensis*	matK	Mahadani and Ghosh, 2013
26	*Indigofera* species	ITS2	Yao *et al.,* 2010
27	*Mangifera* species	matK	Hidayat *et al.,* 2012
28	*Miconia* species	ITS2	Yao *et al.,* 2010
29	*Orchid* species	*matK*	Lahaye *et al.,* 2008
30	*Oxalis* species	ITS2	Yao *et al.,* 2010
31	*Paris* species	ITS2	Zhu *et al.,* ,2010
32	*Phaseoluslunatus*	trnL and ITS2	Madesis *et al.,* 2012
33	*Phaseoluscoccineus*	trnL and ITS2	Madesis *et al.,* 2012
34	*Palmea* species	rcbL, matK	Naeem *et al.,* 2014
35	*Phyllanthus emblica*	matK	Mawalagedera *et al.,* 2014
36	*Phyllanthus* species	psbA-trnH	Srirama *et al*., 2010
37	*Polygala* species	ITS	Yao *et al.,* 2010
38	*Rosa x damascena*	rbcL	Schori and Showalter, 2011
39	*Roseceae* species	ITS2	Pang *et al.,* 2011
40	*Rubus* species	ITS	Yao *et al.,* 2010
41	*Ruellia* species	ITS	Yao *et al.,* 2010
42	*Scaphyglottis* species	ITS2	Yao *et al.,* 2010
43	*Senecio* species	ITS2	Yao *et al.,* 2010
44	*Solanum* Species	rbcL, matK, ITS, trnH-psbA	Techen *et al.,* 2014
45	*Solanum* Species	ITS2	Yao *et al.,* 2010
46	*Taxus* species	nr*ITS*, *trn*L-F	Liu *et al.* , 2010
47	Tea	*rbc*L, *mat*K	Stoeckle *et al.,* 2011
48	*Telipogon* species	ITS2	Yao *et al.,* 2010
49	*Trachyspemumammi*	trnH-psbA	Schori and Showalter, 2011
50	*Trifolium* species	ITS2	Yao *et al.,* 2010
51	*Veronica* species	ITS2	Yao *et al.,* 2010
52	*Zingiberaceae*	matK	Selvaraj *et al.* 2008

Challenges and future perspectives of DNA barcoding

To perform accurate, qualitative and successful molecular experiments, it is important to isolate a pure and high molecular weight DNA from the source. In DNA Barcoding technique, the procedure of extracting DNA from animals was easier as compared to plants because in processed plant materials, the DNA is often highly degraded or the plant material contains high amounts of polysaccharides, polyphenols and other secondary metabolites, such as, alkaloids and flavonoids (Techen *et.al*, 2014). It is also found that the mitochondrial DNA of plants has low substitution rates and a rapidly changing gene content and structure, which make cytochrome oxidase (COX1) unsuitable to work as a barcode in plants. Instead *trnH-psbA* sequence, an intergenic spacer of plastidic DNA, was used a marker specific for plants and fungi. Therefore, plants have not been given much importance in the early stages of this technique (Stoeckle *et.al*, 2010; Sbordoni, 2010).

Various commercial kits and modified traditional methods are available to yield in good quality DNA from raw and powdered plant material or the herbarium specimens.In some cases, inspite of the interrogation done by BOLD, difficulties in identifying the plant species arise when the unknown specimens come from a currently under described part of biodiversity.

Efforts have been made in plant DNA barcoding by many researchers, but the progress in this technique has been hampered by three major factors (Cho *et.al*, 2004):

1. It is difficult to design universal primers for the targeted homologous markers for all plants.
2. The proposed DNA markers can be easily amplified and sequenced in some families or genera but not in others
3. For a given DNA-barcoding marker, the genetic gaps between species are distinct in some plant groups but are lacking in others.

Despite these hurdles, DNA barcoding is in progress in case of plants, where by combining two or three DNA markers to make a standardized plant barcode. CBOL Plant Working Group (2009) proposed to use the combination of *rbcL* + *matK* as a core plant barcode.

Several DNA barcoding markers have been experimented for identification of various plant species where *rbcL* and *matK* have been proved more useful. Besides this technique, the newly developed advanced technologies — the next generation sequencing (NGS) technologies have been gaining popularity. These NGS technologies have the potential to revolutionize the process.

Although DNA barcoding usually targets short regions of DNA molecule within the genome and does not require full genome-scale data, the potential of using NGS to simultaneously identify multiple species or bulk samples of organisms by sequencing DNA barcodes is plenty. The use of NGS technologies and the wide expansion of reference sequence databases have made the NGS approach promising. Therefore, the combination of targeted genomic enrichment and NGS could ultimately make the technologies applicable in DNA barcoding of horticultural plant materials (Techen *et.al*, 2014).

Conclusion

There is an increasing demand and an urgent need to explore and identify the hidden potential of the unexplored and underutilised horticultural crops of this unexplored region. DNA barcoding being a reliable system that rapidly assembles a precise and representative reference library can be an effective technique for authentication, utilisation and conservation of these horticultural plant materials.

Based on the literature analyzed in this review paper, it can be concluded that this technique could be very appropriate tool for the biologists, scientists, horticulturists, hybridisers, research scholars for the scientific and socio-economic development of hot spot region of Northeast India.

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Milk and Human health in Meghalaya: A critical review

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Abstract

Meghalaya is one of the self-deficient states in India in terms of milk production. The per capita availability of milk is 83gms per day (Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Government of India. Though, Government of India has taken initiatives to promote the dairy sector, yet Meghalaya could only contribute around 6.6% of the total amount of milk produced by the North-Eastern States in 2013-14. Hence, to meet the demand of milk and shortage of supply, the sellers are tempted to adulterate the milk as a result 96% of the milk were found non-confirmatory during the National Survey of Milk Adulteration by FSSAI (Food Safety and Standard Authority, Govt. of India). So, it becomes very important for the common people to know about the adulteration and the adulterants used and also the possible health hazards caused by them. Thus, a review study had been done on the causes, steps and various adulterants used in the adulteration of milk. The detection methods available for the common people had also been discussed along with the laws against adulteration.

Keywords: milk adulteration, adulterants, detection tests, FSSAI, DART

Introduction

Milk is the primary source of nutrition for infants and also consumed by young adults, aged persons for their daily nutrition. It is a complete protein food, which fulfils the essential amino acid requirements for vegetarians. Therefore, though occurring from a source of mammary glands of animals, it is still not yet given a proper classification or label of vegetarian or non-vegetarian food by FSSAI (Food Safety and Standard Authority of India). Milk is of high demand in all the corners of the world since time immemorial. With the introduction of white revolution by NDDB (National Dairy Development Board) of India under the leadership of Dr Varghese Kurien, India developed from a milk deficient country to the highest milk producing nation in the world (NDDB, 2018). According to the report of Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, the production of milk in India in 2016-17 is 165.4 million tones and the per capita availability (gm/day) is 355 (NDDB, 2018).

For the assurance of quality, the National Survey on Milk Adulteration, 2011 was conducted by the FSSAI, and it was found that around 68.7% of the milk samples collected from all over India (28 states and 5 union territories) were non-conformity. Northern India's non-confirmatory rate was more than Southern India. The worst performers were Bihar, Chhattisgarh, Orissa, West Bengal, Mizoram, Jharkhand and Daman & Diu, where non-conformity with food safety standards was 100 per cent, while the non-conformity percentage from the samples of Meghalaya was 96 (NDTV, 2018).

An Introduction to Meghalaya's milk status

Meghalaya is the home of ethnic tribes who believe that consuming milk may cause acidity and their food mainly consists of meat (Meghalaya times, 2012). But according to a study by Feroze *et al.,*2011 the demand of milk is expected to increase due to changing lifestyle and increase in per capita income of the people. The geographical locations are not as ideal as of the neighbouring plains, still Meghalaya boosts a total number of 0.91 million cattle with total milk production of 83.6 thousand tones as in 2016-17. Dairy was the primary occupation of 40% sample household, and in an average 14.31L per household were produced and 83.14% was disposed to co-operatives, consumers or private shops. Average sale of milk was Rs 34.14 per litre. (Feroze and Singh, 2017). As per Livestock census 2012, West Garo Hills had the highest bovine population in the state, with crossbreed of 1631 numbers, Indigenous breed of 240914 numbers, buffalo of 4233 numbers, completing a total bovine of 245147 numbers, while Ri-Bhoi District produced the highest quantity of milk i.e., 13.57 thousand tonnes (Government of Meghalaya, 2014). Meghalaya contributed 6.60% of the total milk production in North Eastern States in

2013-14 (Feroze and Singh, 2017).

Thus, production of milk in Meghalaya is low compared to other states. To overcome the milk shortage, The Department of Animal Husbandry and Veterinary Department, Government of Meghalaya, had built three dairy plants at Mawiong (20 000 L), Jowai (8000 L) and Tura (8000 L) and three milk chilling centres are located at Resubelpara, Nongstoin and Latyrke. One creamery and ghee making centre had been established at Ganol in West Garo Hills (Government of Meghalaya, 2018). About 36 Dairy Co-operative Societies are functioning in these two districts East Khasi Hill and Ri-Bhoi are the two milk shed area. One Intensive Dairy Development Board (IDDB) and the nonoperation flood for hilly regions had been established in East Khasi Hills and Ri-bhoi Districts. Two IDDP are under implementation at Jowai and Tura (Feroze and Singh, 2017). A project named Meghalaya Milk Mission (2018-2022) through the National Cooperative Development Corporation (NCDC) worth Rs 215 crore was announced by Union Minister for Agriculture and Farmers Welfare Radha Mohan Singh for Meghalaya Milk Mission for various training under dairy farm, chilling centre and purchase of cattle. Meghalaya's first bull fair was also organised by the Government of India as a step against the high gap between the demand and supply of milk (The Telegraph, 2018).

1. Reasons for Milk Adulteration

Milk is made up of 87% water, which makes it an easy prey for adulteration by the farmers, middle men and brands. Its high nutritive value makes it a good medium for microorganisms especially of bacteria in unhygienic conditions and storage in favourable room temperature.

The shortage of milk is the major factor responsible for adulteration of milk especially in Meghalaya which is due to the deterioration of genetic stock of cow. Meghalaya Government cannot arrange fresh stock because of the ban on import of stock from European and American countries. Since, the demand is high and availability quite less, so the producers are tempted to resort to ideas like adding water to increase the quantity of milk. (The Shillong Times, 2012)

Again, the cost of maintenance of the cattle is also very high as compared to the price in which the milk is sold. A dairy farmer sells milk to the cooperative at the rate of Rs 27 per litre, on the average; he may sell 8 litres per day, which makes his income Rs 200 per day while his expenditures are Rs 300 per day, leading to a loss of Rs 100 per day. Thus, to make up the loss and earn profit, the farmer may resort to adulteration (The Inorganic milk, 2018).

2. Stages of Milk Adulteration

Adulteration may occur at multiple stages:

i. **At farmer's level**: The cattle may be fed cheap fodder adulterated with toxic chemicals. In order to increase production of milk, growth hormones and antibiotics may be given to the cattle, which may be present in the milk as a contaminant. Poor sanitation and health issues may lead to irreversible changes in milk (The Inorganic milk, 2018).

ii. **Collection agent**: The agent collects the sub-standard milk from the farmers, and due to the poor cold-chain infrastructure, adds formalin and hydrogen peroxide as preservatives. The milk is homogenised and pasteurised, and stored for one-two days (The Inorganic milk, 2018).

iii. **Milk brands**: The milk is collected from the agent by the milk brands and is reconstituted with skim milk powder to create variants, which is then supplied for distribution. Adulteration techniques are their business secrets (The Inorganic milk, 2018).

3. Major Adulterants in Milk

According to the National Survey of Milk Adulteration, 2011, the most common adulterant in milk is water. Paul *et al.,*(2011) studied the milk samples in and around Tura, Meghalaya on the day of Shivratri and found that the samples collected from four localities were adulterated with water and the quality did not confer to the standard prescribed by PFA (Prevention of Food Adulteration rules).

Water decreases the nutritional value of milk, and inorder to maintain the SNF, other additives or adulterants like skim milk powder and fat were also added. Water is generally harmless as an adulterant, but the use of contaminated water may lead to various infections and gastrointestinal disorders in the body. (The Shillong times, 2012)

The other adulterants in milk include urea, starch, glucose and formalin as they provide thickness and preserve the food for longer periods (NDTV, 2018).

4. Health Hazards Related to Adulterants

in Milk

i. Water

The primary source of water in Meghalaya is the stream water. This stream water is often contaminated by humans as they eliminate their wastes especially the sanitary wastes into the flowing water of the stream. Due to water shortage in Meghalaya, people are often found in the stream bathing and washing clothes and utensils and some of the water are also carried home for their domestic chores and drinking. The water often gets nonpotable and such water if added to the milk as adulterants would carry the risks of various diseases like arsenic poisoning in Bangladesh and Minamata diseases in Japan which occurred due to consumption of water containing heavy metals like arsenic and mercury respectively (Uddin and Huda, 2011; Harada, 1995). Though such serious diseases have not been detected in the state, but the local people often complain of suffering from diarrhoea, typhoid, dysentery etc. which are mainly water-borne diseases (Hamner *et al.,* 2006). Above that, addition of water decreases the nutritional value of milk. Chemicals may also be added to compensate the density and colourof milk after dilution of the milk with water. (Das *et al*., 2015)

ii. Starch

Starch is usually added to milk to compensate the loss of the extracted fat from milk and also manage the SNF (Solid Not Fat) of the milk when large quantity of water is added to increase the volume of milk. (Afzal *et al*, 2011). High intake of starch is known to cause obesity, high blood pressure, heart diseases, cancer of pancreas, amylophagia. Its accumulation in the body is fatal for diabetic patients. (Muneyuki *et al*, 2012)

iii. Sugar

Sugar is used to mask extraneous water or to elevate total solids in the milk (Azad and Ahmed, 2016). Consumption of excess sugar leads to dental caries (Leme *et al.,* 2006), obesity, increase in cholesterol level in body, and also causes Type I and Type II diabetes. (Gibson *et al*., 2013)

iv. Detergent

Detergents are used as an emulsifier that will dissolve the oil in water giving a frothy solution, the characteristic white colour of milk. Detergents cause gastro – intestinal complications and food poisoning (Singuluri and Sukumaran, 2014). Some detergents contain dioxane, a carcinogenic agent. (Abe 1999)

v. Formalin

Formalin is used as a preservative to increase the shelf life of the milk (Afzal *et al*, 2011). It is highly toxic and may cause cardiovascular toxicity (Strubelt *et al*., 1990). It also causes abdominal pain, diarrhoea, vomiting and other poison related symptoms. (Das *et al.,* 2015)

vi. Vanaspati

Vanaspati decreases the manufacturing costs of milk products and also increases the fat content in milk. Vanaspati is high in transfats, which is dangerous for the heart and may cause heart attack and strokes. (Testing lab, 2017)

vii. Boric acid

It is added as a preservative. Boric acid may cause coughing, eye irritation, vomiting, and oral irritation (Das *et al.,* 2015).It is also classified as a group E carcinogen by the US EPA. (See *et al.,* 2010).

viii. Synthetic milk

Synthetic milk is added to increase the volume of milk. It causes a cancerous effect on the human system and can lead to gradual impairment of the body. (Barak, 2013).

ix. Urea

Urea provides whiteness, increases the consistency of milk and levels the contents of solid-not-fat (SNF) as are present in natural milk. It is also used as a preservative and increases shelf life of the milk. Common health hazards may include acidity, indigestion, ulcers and cancers (Das *et al*., 2015). The the kidneys are overburdened with the presence of urea in milk as they have to filter out more urea content from the body (Singuluri and Sukumaran, 2014).

5. Steps to Detect Adulterants in Milk

The assessment of milk quality had become a prime necessity not only for the dairy sectors but also for the common people. Each adulterant or contaminant can be detected by different sophisticated methods like chromatography, spectroscopy etc. Scientists have developed analytical techniques like freezing point osmometry, capillary electrophoresis, thermometric sensors, mass

spectrometry, least-squares support vector machine (LS-SVM) for detection of adulterants (starch, sucrose etc) in milk. But these techniques are sophisticated, expensive and time- consuming. The kits are not available for the general people who are the consumers of milk rather they require qualified personals to handle them (Das *et al*., 2015). Hence, FSSAI came up with a kit, Detect Adulteration with Rapid Test (DART) to enable the consumers to detect the quality of milk by their own. The eBook is available online in the *fssai* website and can be downloaded free of cost (FSSAI, 2018). For those who cannot reach certain chemicals for the tests, Government of India came up with the initiative to set up portable and easy to operate milk adulteration kits at affordable prices. An example is the milk adulteration detection kit developed by Biosyl Technologies in Karnataka which is available at the cost of Rs 50 and can detect 6 adulterants with a value as low as 0.5% of the contaminant (Business Standard, 2018). FSSAI is also developing a kit which will be available for Rs 15-20 (The Economic Times, 2018). DRDO (Defence Research and Development Organisation) of India had also developed a milk adulteration kit to detect detergents which is easily available. (The News minute, 2016). On 17th March 2017, the Science and technology minister Harsh Vardhan informed the Lok Sabha that a scanner had been developed that would detect various adulterants and the cost of the machine would be around Rs 10,000 while a test would cost 5-10 paisa (The Times of India, 2016).

In Meghalaya, Meghalaya health and family welfare minister, Mr. A.L. Hek launched "FoodSafety on Wheels", a mobile food testing laboratory, at Health complex, Shillong on 4th May, 2018. The vehicle was funded by FSSAI and costed Rs 37 lakhs with an annual maintenance of Rs 5 lakh per year. Food Safety on Wheels is a multifunctional mobile laboratory for spot detection of adulterants in food items. The Mobile Food Testing laboratory, under the Commission of Food safety, Shillong, will help in reaching out to the food from unorganised business sector and remote places and thereby check its quality. It will also conduct awareness programmes and training for consumers, food business operators, school children, besides transporting food samples from remote areas to Food Testing Laboratories (The Shillong Times, 2018). A team from Hyderabad based Vimta lab appointed by FSSAI was on a tour to Northeast to test and determine the quality of milk sold to consumers. The team had collected samples from Tura and Shillong and the samples had been sent to State Public Health Laboratory. (The Shillong Times, 2018).

6. Laws against Adulteration in India

Adulteration comes under the Food Safety and Standards Act, 2006, and the power to exercise it rests with State Governments. The FSSAI regulations provide various punishments to persons who adulterate food or food products as under: (FSSAI, 2017)

- A minimum imprisonment of six months that may extend up to 3 years and a minimum fine of Rs 1000 as a penalty will be imposed on the Import, manufacture, storage, sale or distribution of any food article whose quality or purity is below the prescribed standard or misbranded.
- The penalty for Import, manufacture, storage, sale or distribution of any adulterant not injurious to health is minimum imprisonment of six months that may extend up to 3 years and minimum fine of Rs 1000.
- If a Food Inspector is prevented from taking a sample or exercising his duty then the minimum imprisonment is of six months that may extend up to 3 years and a minimum fine of Rs 1000.
- The penalty of giving a false warranty in writing in respect of any food article is minimum imprisonment of six months that may extend up to 3 years and minimum fine of Rs 1000
- The penalty of Import, manufacture, storage, sale or distribution of any food article which is adulterated or any adulterant which is injurious to health is being used is minimum imprisonment of one year that may extend up to 6 years and a minimum fine of Rs 2000
- Sale or distribution ofany food article containing any poisonous or other ingredients injurious to health, which is likely to cause death or grievous bodily harm will have minimum imprisonment of three years that may extend up to life and a minimum fine of Rs 5000. (FSSAI, 2017)

Recently, FSSAI had proposed amendment in its previous act and said "Any person who adds an adulterant to food so as to render it injurious for human consumption with an inherent potential to cause his death or is likely to cause grievous hurt, irrespective of the fact whether it causes actual

injury or not, shall be punishable for a term which shall not be less than 7 years but which may extend to imprisonment for life and also fine which shall not be less than Rs 10 lakh,"(The Economic Times, 2018).

Conclusion

Milk is an important food item but the present status of milk in Meghalaya where 96% of the milk samples were non-confirmatory is a big threat to the state. The non-confirmatory state of milk is mainly due to the adulteration. The adulterants pose a great risk to the health and the process of adulteration has to be checked. In a state like Meghalaya, many people are still not aware of it. Though, FSSAI and The Government of India have come up with various programmes to fight against adulteration, it is also the duty of the common people to follow the guidelines provided by Government and FSSAI to be aware of such crimes and take necessary precautions to be safe.

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SHORT COMMUNICATION

Status and technologies suitable for enhancing productivity of oilseed crops in North Eastern Hills region

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Abstract

The article reviews the status and opportunities to enhance the productivity and area expansion for doubling farmers' income in North Eastern Hill (NEH) region of India. With the present trend of consumption of edible oil (18 kg per capita), the demand of vegetable oil in the country would be around 33.2 mt (4.12 mt for industrial use) and 41 mt for 2022 and 2050, respectively. The vegetable oil availability from secondary sources such as coconut, cotton seed, rice bran, and tree & forest origin has been estimated to the tune of 5.22 mt by 2022. Thereby, the vegetable oil requirement from the nine annual oilseeds would be around 27.98 mt by 2022 including requirement for industrial use. Thus, the present level of production of oilseeds has to be increased by almost 1.5 times by 2022 and 2.6 times by 2050 in less area and with predicted less rainfall because of climate change! The per capita availability of oilseeds in the NEH region is about 8 g as against moderate requirement of 50 g a day. Thus, substantial quantities of oils are brought into the region from outside to meet the requirement. In NEH region, the productivity (973 kg/ha) of oilseeds is lower than national average (1229 kg/ha). To increase area, production and productivity of oilseeds in this region, there is need for crops specific approaches, which should be adopted in the overall framework of systems approaches. It includes short duration varieties, agronomic management with INM, IPM, IDM practices, conservation agriculture like Zero-till in rice and maize fallow areas in NEH Region.

Key words: **Oilseed crops, INM, IPM, IDM, Zero till**

Introduction

The oil extracted from oilseeds form an important item of our diet and are used as raw materials for manufacturing large number of items like paints, varnishes, hydrogenated oil, soaps, perfumery, lubricants, etc. India remains the world's second-largest edible oil consumer after China, meeting nearly 70% of its annual requirement through imports. It produces around 8 million tonnes of edible oil and 15 million tonnes being imported (2015-16). With the present trend of consumption of edible oil (18 kg per capita), the demand of vegetable oil in the country would be around 33.2 mt (4.12 mt for industrial use) and 41 mt for 2022 and 2050, respectively. The vegetable oil availability from secondary sources such as coconut, cotton seed, rice bran, and tree & forest origin has been estimated to the tune of 5.22 mt by 2022. Thereby, the vegetable oil requirement from the nine annual oilseeds would be around 27.98 mt by 2022 including requirement for industrial use. Thus, the present level of production of oilseeds has to be increased by almost 1.5 times by 2022 and 2.6 times by 2050 in less area and with predicted less rainfall because of climate change!

All India Scenario of oilseeds

The highest area, production and productivity were higher in soybean among the oilseed crops during 2014-15 to 2016-17 (Table 1). Production of oilseed could be boosted with triple approach with improving productivity from currently (968) to 1980.5 (kg/ha) during 2050. The bitter reality is that the average productivity of oilseeds in India is around 1.0 t/ha, which is far below that of the developed countries (2.5-3.0 t/ha) and of the world average (2.15 t/ha). This can be easily achieved in stipulated course of time with systematic approach and technological advancement. Secondly very limited scope is available for horizontal expansion only 0.423 Mha is possible whereas at national level scope is much wider to the extent possible of 6.68 Mha (Chand, 2009; Chand & Singh, 2012). India will be self-reline country from net importer to net exporter as our estimated produc-

tion touchdown all time high (66.35 Mt) as against our requirements (59.40 Mt) with surplus out production of 6.95 Mt during 2050-51(Table 2).

Table 1. Area, production and productivity of important oilseeds in India

A=Area(mha), P=Production(mt) and Y=-yield(kg/ha)

Crop	2014-15			2015-16			2016-17		
	A	P	Y	A	P	Y	A	P	Y
Groundnut	4.77	7.40	1550	4.60	6.73	1465	4.56	6.77	1486
Soybean	10.91	10.37	951	11.61	8.57	738	11.67	8.59	737
Rapeseed-Mustard	5.80	6.28	1083	5.75	6.80	1183	5.76	6.82	1184
Sesamum	1.75	8.28	474	1.95	8.50	436	1.95	8.5	436
Linseed	2.86	1.55	541	2.63	1.25	477	2.63	1.25	477
All INDIA	**25.60**	**27.51**	**1075**	**26.13**	**25.30**	**968**	**26.18**	**31.28**	**1229**

Source: Directorate of Oilseed Research, 2016, & DoES, MoAFW 2016

Table 2. Projected Area, production, productivity and requirement of oilseeds in India (2050)

Population (million)	Additional area (mha)	Total area (mha)	Production (mt)	Productivity (kg/ha)	Requirement (mt)	Import (mt)
1685.21	6.68	33.5	66.35	1980.5	59.40	6.95

Source : (Chand, 2009; Chand & Singh, 2012)

Constraints of oilseed production in NEH

- ❖ Low priority of oilseeds with use of marginal land
- ❖ Use of low quality seeds & varieties
- ❖ Non-vegetarian food habits of NEH people
- ❖ Lack of rain water conservation & irrigation facilities
- ❖ Al-toxicity & phosphorus deficiency
- ❖ Lack of suitable varieties
- ❖ Low or imbalanced input use, credit and farm tools
- ❖ Major area falling under rainfed situation
- ❖ Poor adoption of improved technology
- ❖ Lack of marketing infrastructure

Scenario of oilseed in NEH region

The major oilseed crops grown in NEH Region are groundnut, soybean, rapeseed and mustard, sesamum and linseed. The oilseed scenario in the North –Eastern Hill (NEH) Region is also very bleak. Although the production and productivity of oilseeds in the region is in increasing trend. The per capita availability of oilseeds in the region is about 8 g as against moderate requirement of 50 g a day. Thus, substantial quantities of oils are brought into the region from outside to meet the requirement. In NEH region, the productivity (973 kg/ha) of oilseeds is lower than national average (1229 kg/ha).The data on oilseeds in NEH in Table 3 showed that the highest area (65.5 thousand hectare) and production (68.6 thousand tones) in Nagaland among the hill region of North- East India, whereas lowest area and highest productivity(1109 kg/ha) was in Mizoram. Similarly, crop wise data showed that the highest area and production in rapeseed and mustard but highest yield (1195 kg/ha) in soybean (Table 4). Expansion of

area of groundnut, soybean, rapeseed and mustard, sesame and linseed in about 1.5 mha in rice and potato fallows. Additional 1.73 mha can be targeted in non-traditional areas in different states including NEH region. This will fetch additional production of oilseeds by 5-6 mt. In NEH region, the productivity (973 kg/ha) of oilseeds is higher than national average (968kg/ha).

Table 3. State wise area, production and yield of oilseeds in NEH Region (2015-16)

State	Area(000ha)	Production (000tonnes)	Yield (kg/ha)
Arunachal Pradesh	35.0	36.4	1040
Manipur	37.5	31.8	847
Meghalaya	13.9	15.2	1091
Mizoram	2.7	3.0	1109
Nagaland	65.5	68.6	1047
Sikkim	6.9	6.3	909
Tripura	11.7	9.0	771
NEH	**173.2**	**170.3**	**973**

Source: Directorate of Oilseed Research, 2016

Table 4. Area, production and yield of oilseed crops in NEH region of India(2015-16)

Crop	Area ('000ha)	Production ('000tonnes)	Yield(kg/ha)
Groundnut	6.3	6.2	984
Soybean	38.9	46.5	1195
Rapeseed- Mustard	106.3	102.6	965
Sesamum	12.3	8.2	667
Linseed	5.9	4.8	814
Total oilseeds	**173.2**	**170.3**	**983**

Source: Directorate of Oilseed Research, 2016

Opportunities to meet the requirement of oilseeds in NEH

- ❖ Horizontal Expansion of oilseed area
- ❖ Vertical Expansion- Productivity enhancement
- ❖ Reducing cost of cultivation
- ❖ Reducing post harvest losses
- ❖ Creating irrigation facilities
- ❖ Creating processing infrastructure & marketing linkages

Options to enhance productivity oilseeds in NEH

- ❖ Adoption of improved varieties itself can enhance productivity by 20 to 25%.
- ❖ Judicious use of manures and fertilizers
- ❖ Integrated Nutrient Management including biofertiliser and micronutrients
- ❖ Integrated Pest& Disease Management
- ❖ Efficient use of water and conservation agriculture (Mulching, Zero tillage etc)
- ❖ Agronomic management practices can be substantially increased the productivity of oilseeds in NEH Region if these technologies are adopted by farmers.

Suitable varieties of oilseeds in NEH region

Crop	Suitable varieties for NEH Region
Groundnut	ICGS 76, ICGS 44, BAU 13, TKG-19A, TG-1A, JL-24, ICGV-86590, ICGV- 91114, TPG-41, TG 37A, GPBd-4, TG 38, Kadiri -6, GG20, VRI 8 (VG 09220) etc.
Rapeseed mustard	**Rapeseed (Toria):** M 27, TS 36, TS 38, TS 46(Lakshmi), TS67, Tripura Toria (TRC T-1-1-5-1) **Yellow Sarson**: Ragini, YSH-401 **Mustard:** TM2, TM4, Varuna, PM27, PM 28, PM 29, Pusa Agrani, Pusa Mahak, NRCHB-101, PM25
Soybean	JS 80-21, Bragg, JS 89-2, PK 71-21, JS-95-60, JS 97-52, UCS 1-10, PK-1042, PS-1347, Pant Soybean 24 (PS 1477),Pant Soybean 21 (PS1480), Pant Soybean 23 (PS1 523), PK-472,
Sesamum	OMT-3, RAUSS-17-4, Nimphy, JLT-26, B-67, AH-8, AH-7, TKG-22, TC 25, SP 1181(Madhavi), Gouri, Vinayak, ST 1683, Punjab Tall No. 1, GT 3, GT10, AST 1, TRIPURA SIPING (TRC TIL 1-8-1-1), TRC-T12 1-8, Savitri,Amrit, Sesamum var. Vinayak, local white and black seeded cultivars are also popular in the region, TC25, Vinayak
Linseed	T-397, Padmini, NL 165

Integrated nutrient management (INM)

- Compost/vermicompost 2-2.5t/ha + NPK(50%RD) enhance yield and left maximum residues for second crop.
- Zinc sulphate @25kg/ha + lime @500kg /ha or spray 0.5% zinc sulphate plus 0.2% lime.
- NPK (RD)+ lime@200kg/ha
- *Rhizobium* culture according to crop (eg. NC-92, TAL-1000, IGR-6 and PGPR found to increase pod yield by 5-6q/ha and *Bacillus polymyxa* and *Aspergillus spp* (NRCG isolation) increased pod yield by 6-7 q/ha in groundnut).
- Borax @ 5-10 kg/ha are recommended, in addition to recommended dose of fertilizers.
- Application of *Azotobacter* along with nitrogen help in increasing seed yield of rapeseed mustard
- Residual effect of lime, applied during kharif season in groundnut and soybean increased seed yield of mustard in subsequent rabi season.

Integrated pest management (IPM)

- Deep ploughing during April-May to expose pupae to sunlight and predatory birds.
- Clean cultivation by rouging out weed hosts and self-sown plants.
- Growing of resistant varieties
- Early sowing escapes the damage caused by Leaf Miner and White Grubs.
- Set up the petromax light traps @ 1-2/ha to attract and kill the moths during June-August.
- Install pheromone traps @ 10 traps/ha for Spodoptera and Helicoverpa and 25 traps/ha for leaf miner.
- Spray neem oil @5ml/lt water alongwith suitable surfactant like soap powder @ 1g/lt or NSKE 5% as it acts as oviposition deterrent.
- .Spray entomo-pathogenic fungus like, *Nomuraea rileyi* and *Beauveria bassiana* @ 2g/lt of water for lepidopteran Caterpillars and *Verticillium lecanii* for sucking pests.
- Termite and white grub cut and feed the roots

leading to wilting and death of plants and to control these, treat seed with chloropyriphos 20EC@12.5ml//kg of seed or apply 40-50kg/ha before sowing or soil treatment with thimet10G@20-25kg/h or carbofuran@1.5 kg a.i./ha.

Integrated disease management (IDM)

- Deep burial of surface organic matter and crop debris.
- Use good quality seeds of resistant/tolerant varieties.
- Seed treatment with commercial formulation of *Trichoderma harzianum* or *T. viride* or *Pseudomonas fluorescens* @ 10g/kg seed or Thiram or Carbendazim or Captan or Mancozeb @ 3-4g/kg seed or Tebuconazole (Raxil 2 % DS) @ 1.25g/kg.
- Avoidance of deep sowing and injury to the seedling.
- Soil application of neem cake or castor cake @ 500kg/ha or neem seed kernel powder @ 3-5%.
- Foliar application of Carbendazim (0.025%) + Mancozeb (0.2%) at 2-3 weeks interval effectively reduces the early leaf spot and late leaf spot severity.
- Spray Mancozeb (0.2 %) or Copper Oxychloride (0.2 %) and destroy the collateral weeds and self-sown plants.

Cropping systems suitable for NEH region

- Maize + frenchbean/cowpea- mustard
- Maize-mustard
- Rice- mustard
- Rice- linseed
- Groundnut- mustard
- Groundnut +citrus
- Groundnut + pineapple .
- Maize + groundnut (2:2 or 1:2) and Upland rice + groundnut (3:1 or 4:2 row ratio) can gave additional yield of groundnut by 6-8 q/ha.
- Maize + soybean1:2 kharif- mustard rabi
- Maize+ groundnut 1:2 kharif-mustard(rabi)
- Straw/weed mulching play an important role by conserving moisture in rabi oilseed production under upland/jhum condition.

Agronomic management of oilseeds in NEH region

1. **GROUNDNUT *(Arachis hypogaea L.*)**

Groundnut is the most important oilseed of India and accounts for a little less than half of the major oilseeds produced in the country. Groundnut kernels are rich in proteins and vitamins and have high calorific value. It is energy rich crop and contains 25 to 30% protein, 5 to 15% carbohydrate and 45-55 per cent oil which is mainly used as edible oil in its pure form or hydrogenated vanaspati form. The groundnut oils is also used for manufacturing margarine, medical emulsions, wool and silk, artificial leather, soap and toilet requisites. Groundnut is eaten raw, roasted, sweetened or salted. Its oil cake is used as an important rich cattle feed. It serves as an important rotation crop because it sysnthesizes atmospheric nitrogen and increase the fertility of soil. With high yielding varieties and improved agronomic practices, the production can be increased easily which can cover the gap between demand and supply. Groundnut is not a traditional crop of NEH Region, but it is highly potential crop under existing upland rice and maize based cropping systems.

Soil Type: Well drained sandy loam and loamy soil is suitable. Foot hills, dry terraces and flat lands of NEH region are suitable for groundnut cultivation.

Land Preparation: Land should be prepared to a fine tilth by 3-4 ploughings followed by laddering. Deep ploughing should be avoided. Ploughing depth should not exceed 15 cm.

Time of sowing: May –June upto 1st week of July.

Seed Rate: 95-100 kg kernel/ha

Seed Treatment: Thiram or Captan@ 3g/kg of kernel or Mancozeb @ 3 g/kg seed. *Trichoderma viride* seed treatment @ 4 g/kg seed for rot prone areas. *Rhizobium* inoculation (@ 600 g/ha is necessary for

groundnut in non-traditional areas **Method of Sowing:** Row to Row : 30 cm ; Plant to Plant : 10 cm

Depth of sowing: 5 cm

Harvesting: The stage of harvesting is attained when the vine begins to turn yellow and leaves start shedding. Harvesting is done by digging out the pods.

Yield: 25 – 30 q/ha

2. RAPESEED AND MUSTARD (*Brassica spp.*)

Among the rabi oilseed crops, rapeseed and mustard can play an important role in the North –Eastern Hill (NEH) region to boost oilseed production. In this region, rapeseed –mustard can be successfully grown as rabi crop upto mid altitude (<1300 m above MSL) and yield level of 8-12 q/ha can be achieved by adopting improved production technology. The oil content of these seeds is 30-45% which is used as a cooking medium, preservative for pickles, lubricants and toiletteries. Oil cake forms an important cattle-feed and is also used as manure.

Soil Type: All type of soils but well in sandy light soils.

Field Preparation: 3- 4 ploughing followed by laddering in order to obtain a fine tilth.

Seed Rate: Line sowing = 4-5 kg/ha, Broadcast = 5-6 kg/ha

Time of Sowing: Last week of September to middle of October but delayed upto to middle of November.

Seed Treatment: Seed treatment with metalaxyl 35 WS @ 6 g/kg of seed is recommended for eliminating downy mildew and White rust.

Method of sowing: Row to row distance = 30-45 cm, Plant to plant distance = 4-5 cm

Seed depth = 2-3 cm

Bee pollination: For enhancing yield through increased pollination, 5 honey bee colonies/ha is recommended in rapeseed-mustard.

Cropping system:

(a). **Dry upland situations:** Maize-mustard, Maize + Frenchbean- mustard, Rice –mustard, frenchbean-mustard, groundnut-mustard.

(b**). Lowland with raised beds:** Maize-mustard, Rice –mustard, Rice-mustard-tomato/potato, cabbage, broccoli, coriander+mustard,

- Resource Conservation practices in maize-mustard cropping
- Zero till cultivation of rapeseed –mustard in rice fallow are most effective technology for NEH region for higher seed production and resource utilization.
- Mulching with straw or thin black polythene enhance production of seed with conservation of soil moisture, reduces weed growth and maintain soil temperature.

Harvesting: The crop is ready for harvest when 75-80% siliquae turn yellow. The crop is harvested by pulling out whole plants or cutting by sickle. Moisture content of less than

8% is suggested or storage. Mustard grain could be safely stored in open rooms.

3. SOYBEAN (*Glycine max* L. Merrill)

Soybean is one of the most important protein as well as oil seed crop. It supplies approximately 65% world protein meal and 20% of the world edible oil. It is reported that more than 400 different products are prepared from it. Soybean seed contain about 37-42% good quality protein, 6% ash, 29% carbohydrate and 17-24% oil comprising 85%poly-un saturated fatty acid with two essential fatty acids (Linoleic and linolenic acid), not synthesized by the human body. It is cultivated as a kitchen garden crop and consumed as pulse by the people in NEH region. It grows well in slopes and terraces. It can be grown as pure and intercrop with maize, ragi, arhar etc

Sowing Time: May-June in mid and low altitudes at the onset of monsoon upto July

Soil: Fertile well drained loamy soils with good drainage.

Land Preparation: 2-3 deep ploughing followed by laddering. There should be provision of surface drains with gentle slope for good drainage.

Seed Rate :

(a) Branched type (Bragg, Alnkar, Ankur, Silajit, PK 271, and PK 262): 60 kg/ha

(b) Less branching type (JS 2, Moti, Kalitur and Pusa soybean): 75 kg/ha

(c) Late sown crop: 80 kg/ha.

(d) Germination is affected if it rains within 72 hours of sowing.

Method of planting: Row to row distance:45 cm Plant to plant: 5 to 10 cm

Depth of sowing:2-3cm.

Seed treatment: Treat with captan or bavistin@2g/kg seed to prvent infestation of seed borne diseases.

Seed Inoculation: The seed should be moistened with clean water with care so as to avoid excessive wetting. *Rhizobium* culture should be mixed with seeds @ 15 g/kg so that a thin coat of inoculum is deposited on each seed. The inoculated seeds should not be exposed to the sun.

Cropping system: Intercropping of soybean with maize (2:1) and rice (4:1) has been found promising in NEH region. The most suitable cropping systems found were maize + soybean (1:2) in kharif- mustard (rabi) and maize + groundnut (1:2 in kharif)-mustard (rabi).

Harvesting and Threshing: Harvest when 90-95% pods turn yellow

Dry for 5-6 days before threshing

Seed Storage: The grains should be dried before storage to ensure that the moisture content of seeds does not exceed 10 per cent. Seeds can be stored in dry bins or polythene bags. (250 gauge thickness) in airtight condition. Bins should be kept on wooden racks so that it does not come in direct contact with the ground. Treatment of seeds with Thiram (@ 3g/kg of seed) is absolutely necessary when stored for seed purposes.

4. **SESAMUM** (*Sesamum indicum L*)

Sesamum commonly known as *til*, grown as pure as well as component mixed crop with arhar, maize, jowar and groundnut. It contains 18-22 per cent protein and high quality 46 to 52 per cent oil which is used for cooking purposes and for manufacturing perfumery and medicines. Its seeds are eaten in fried form mixed with sugar or gur. Its oil-cake is fed to milch cattle

Soil: Well drained light sandy and clay loam soils.

Seedbed preparation: 2-3ploughings followed by laddering/planking

Time of Sowing: June-July in kharif, March in summer and October-November in rabi

Seed Rate: (a) Line sowing**:** 4 kg/ha

(b) Broadcasting : 6kg/ha.

Method of planting: Row to row distance 30-45 cm, Plant to plant distance 10-15 cm

Seed depth 2 to 2.5 cm.

Harvesting: Sesame crop matures in about 100-120 days. Harvest when 75 % capsules mature and turn yellow. Stack the bundles keeping the pods upward

Threshing: Dry for one week and then collect the seed just by inverting the plants

Yield: 6-8 q/ha.

5. **LINSEED** ***(Linum usitatissimum L.)***

The oilseed flax (linseed) is predominantly the source of valuable oil, in which the most appreciated are omega-3 and omega-6 fatty acids. It is a long day plant and cultivated in 34 countries of the world. It is one of the major agro-industrial oilseed crops. Its seed contains 33-43% oil of drying type and 24% protein. Its oil has high percentages of unsaturated fatty acids; it is mainly used in paint and varnish industries. Moreover, its oil contains 75% linolineic acid and 17% linoleic acid. This oil has a unique drying property and is used for manufacturing paints, varnishes, printing ink, oil-cloth, and water-proof fabrics. It is also used as an edible oil in some parts of the country. It is predominantly the source of valuable oil, in which the most appreciated are omega-3 fatty acids. The extensive biochemical analysis of linseed oil resulted in the identification of its other components with potential application in improvement of human health. The focus is now on them and they are of particular interest for human nutrition, cosmetic and pharmaceutical industry. Linseed plant also provides seedcakes (linseed expeller), fibers and shives as by-products.

Soil: Light sandy to Loamy soils

Field Preparation: 3-4 times, followed by 1-2 laddering to obtain a fine tilth.

Time of sowing: Mid October to mid November. Sowing could be done in December after harvest of sali paddy.

Seed Rate: 15-20 kg/ha

Method of sowing: Row to row distance: 30 cm, Plan to plant:10 cm

Harvesting: The crop is ready for harvest when plants become dry and the leaves fall of completely.

Storage: Store at about 8 to 10 percent moisture level in dry place

Conclusion

The productivity of oilseed crops in NEH Region is lower than all India average indicates its bright prospects for enhancing production in NEH Region of India. To increase area, production and productivity of oilseeds in this region, there is need for crops specific approaches, which should be adopted in the overall framework of systems approaches. It includes short duration varieties of oilseeds as inter and/or catch crop especially in rice/ maize fallow areas, development of multiple disease-pest resistant and high biological N fixation varieties etc. Substantial area under shifting cultivation may slowly be diverted for production of oilseed crops following principles of conservation agriculture, which would help in conserving soil and improving its health. Even, if 20-30% rice–fallow area becomes available, region may become self-sufficient in oilseed production. Zero-till has very good potential for oilseed cultivation in rice and maize fallow areas that would save time, labour and other resources. Marketing, storage, postharvest technology, crop insurance are necessary to encourage farmers to grow more oilseed crops in NEH Region.

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