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Indigenous alder based farming practices in Nagaland, India: A sustainable agricultural model

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Abstract

Traditional alder (*Alnus nepalensis*) based agroforestry system is an age-old ecological farming practice of some indigenous tribes *viz*., Angami, Chakhesang, Chang, Yimchunger and Konyak of Nagaland state in India. Alder is a deciduous or semi-deciduous tree naturally grown throughout the Himalayas. In this system of farming, crops are grown as intercrop with alder trees. Agricultural crops co-cultivated with alder forms a very remunerative agroforestry system. Alder does not require high soil fertility and hence, conversion of wasteland into agricultural land through this system is very much practicable. This system is an outstanding sustainable model of land use evolved through numerous years of testing among the indigenous tribes of Nagaland. The present review presents a comprehensive overview of indigenous alder based farming practices in Nagaland. Furthermore, the paper also describes the opportunities, challenges and future research directions towards developing and utilizing this model for sustainable agriculture.

Keywords: Alnus nepalensis, Alder, Jhum, Agroforestry, Sustainable agriculture

Introduction

Nagaland is a mountainous state in the north eastern fringe of India, located between 93°20'-95°15'E longitude and 25°6'-27°4'N latitude with a total geographical area of 16,579 km^2. The total population is about two million (Census of India, 2011). More than 70% of the population is dependent on agriculture and related activities. Terrace and shifting/slash and burn, locally referred to as *jhum* cultivation are the most predominant farming practices in the State. Out of the total cultivable area of 7,21,924 hectares, about 1,01,400 hectares are under *jhum* and terrace cultivation. *Jhum* cultivation is the most primitive cultivation practice of the tribes of north east India. This ancient system of farming is believed to have originated in the Neolithic period around 7000 BC (Borthakur, 1982). *Jhum* cultivation is a land use system described as based on a traditional, year round, community wide, largely self contained and ritually sanctioned way of life. The socio-cultural life of the practicing communities is woven around it and is regulated according to *jhum* calender (Katherine, 1991). Today scientists view *jhum* cultivation as an exploitative system, wherein the land and natural resources are not managed optimally and is taken to be a major cause of deforestation and a faulty land use practice having very low output-input ratio (Tripathi and Barik, 2003; Gupta, 2005). Agriculture practices in Nagaland are organic by default (Yadav *et al*., 2004). In *jhum* cultivation, the vegetation is slashed, burned, tilled and sown. After a year or two of culturing, the land is left fallow so as to regain its fertility (Yano and Lanusosang, 2013). When the cycle lasts for 15-20 years, *jhum* is sustainable. However, increasing population has led to shortened *jhum* cycle resulting into land degradation and non-sustainability of *jhum* cultivation (Rathore *et al*., 2010). Terrace cultivation is an alternative system for sustainable agriculture; however, extensive parts of the state are too hilly and undulated, limiting the replication of terracing models for a wide-scale use.

Agroforestry

Agroforestry is the intentional integration of trees and shrubs into crop and animal farming systems to create environmental, economic and social benefits. Various studies have suggested that agroforestry is more profitable to farmers than agriculture or forestry for a particular area of land (Chavan *et al*., 2015*).* A comprehensive analysis indicated economic viability with internal rate of return (IRR) ranging from 25 to 68 and B : C ratio of 1.01 to 4.17 for 24 agroforestry systems from different agro-climatic regions of the country (Planning Commission, GoI 2001).

Traditional alder (*Alnus nepalensis*) based agroforestry system is an age-old ecological farming practice of some indigenous tribes of Nagaland state in India. In this system of farming, crops are grown as intercrop with alder trees. Agricultural crops co-cultivated with alder forms a very remunerative agroforestry system. Amelioration of *jhum* land by alder tree is a traditional cultivation system using self-reliant and locally available resources without any external inputs. Alder does not require high soil fertility and hence, conversion of wasteland into agricultural land through this system is very much practicable. This system is an outstanding model of sustainable land-use evolved through numerous years of testing by the indigenous tribes and widely practiced in Khonoma village of Nagaland (Rathore *et al*., 2010; Das *et al*., 2012;Yano and Lanusosang, 2013).

General description

A. nepalensis is a non-leguminous deciduous or semi-deciduous tree belonging to the family Betulaceae. It is a rapid colonizer of gravelly and old cultivated lands that are frequently unstable. Alder tree can grow up to a height of 30 m and 60 cm in diameter. The leaves are alternate, simple, shallowly toothed, with prominent veins parallel to each other, 7–16 cm long and 5–10 cm broad. The flowers are unisexual, female and male flowers in separate inflorescences called catkins. Male catkins 10-25 cm long, drooping, in terminal panicles. Female catkins 1-2 cm long, 3-8 together in axillary racemes. Alder fruits are dark brown, 1.5-2 cm long, upright on short stalks, elliptical and with woody scales. Seeds are light brown, circular, flat nut, with membranous wing (Firewood Crops, 1980; *Joker, 2000*).

Geographical prevalence

A. nepalensis is known by various common names *viz*., Himalayan alder, Indian alder, Nepal alder, Nepalese alder, and ni po er qi mu. It is naturally grown throughout the Himalayas *viz*., Pakistan, eastern Nepal, Bhutan, northern India, south-western China, upper Myanmar and parts of Indo-China. Nagaland, which falls under Eastern Himalayan zone, is home to this species.

Alder is a fast growing tree usually grown at 500–3000 m of elevation. It prefers moist, cool climates with mean annual temperature of 13-26°C. Mature trees are tolerant to frost. It is a pioneer species of degraded lands and does not require fertile soil but prefers permeable soils. It is best suited in deep volcanic loamy soils, moist and well-drained but not waterlogged, also grows on clay, sand and gravel, where the mean annual rainfall exceeds 800 mm and the relative humidity is higher than 70% (Firewood Crops, 1980; *Joker, 2000; Rathore et al., 2010).*

Indigenous alder based agroforestry

The indigenous alder based agroforestry is unique and efficient system of sustainable agricultural farming system developed and practiced since time immemorial by some indigenous tribes *viz*., Angami, Chakhesang, Chang, Yimchunger and Konyak of Nagaland state in India (Gokhale *et al.,* 1985; Das *et al.,* 2009; Singh, 1992) (Fig.1). In Nagaland, a number of crops such as rice, tapioca, potato, colocasia, large cardamom, turmeric, etc., are grown as intercrop with alder trees; the trees are allowed to grow and are later used for timber purposes. The root nodule of alder is responsible for fertilizing the soil whereas, the spreading nature of the roots helps in preventing soil erosion in slopes (Rathore *et al*. 2010; Das *et al*. 2012). In this system of sustainable farming, the seedlings are planted in *jhum* field maintaining a spacing of 3-4 m between plants and 5-6 m between rows. In the first year, primary crops (rice) and secondary crops (amaranthus, colocasia, chilli, tapioca, potato) are grown intermixed in the *jhum* field. The cropping operation is repeated in the second year. Subsequently, the field is left fallow for about three years to allow the alder trees to grow and attain rough fissures on the bark. Pollarding and cropping in the subsequent cycle is usually practiced after the tree attains a height of about 2 m. Pollarding of alder trees is usually carried out in two phases; Initial pollarding and cyclical/subsequent pollarding. In the first phase, alder trees are pollarded when the bole circumference reaches 50 to 80 cm and bark develops rough fissures (about 5-10 years). In the cyclical pollarding phase (after 4-6 years), the main trunk is cut horizontally at a height of 2 m or above from the ground, while taking care to avoid splitting of pollarded stump head. This is followed by covering the head with mud/straw to prevent it from excessive drying. In order to facilitate the uniform sprouting of new shoots around the stump, a stone slab is usually placed on the head for this purpose. During the cyclical/ subsequent pollarding phase, the coppiced stumps are allowed to grow in the first year. However, during the second year, about 4 to 5 shoots are retained and the rest are slashed. These shoots are allowed to grow till the next *jhum* cycle and the same process is repeated (Cairns, 2007; Pulamte, 2008; Das *et al*., 2012). The deep root systems of alder give stability to slopes that tend to slip and erode. It is planted to improve the stability of slopes liable to erosion and landslides, also used as a shade tree and for mine reclamation (Rathore *et al*., 2010). Thus amelioration of *jhum* land and stabilization of slopes by alder trees led to a very remunerative and useful agroforestry with sustainable agricultural model in the hill state of Nagaland.

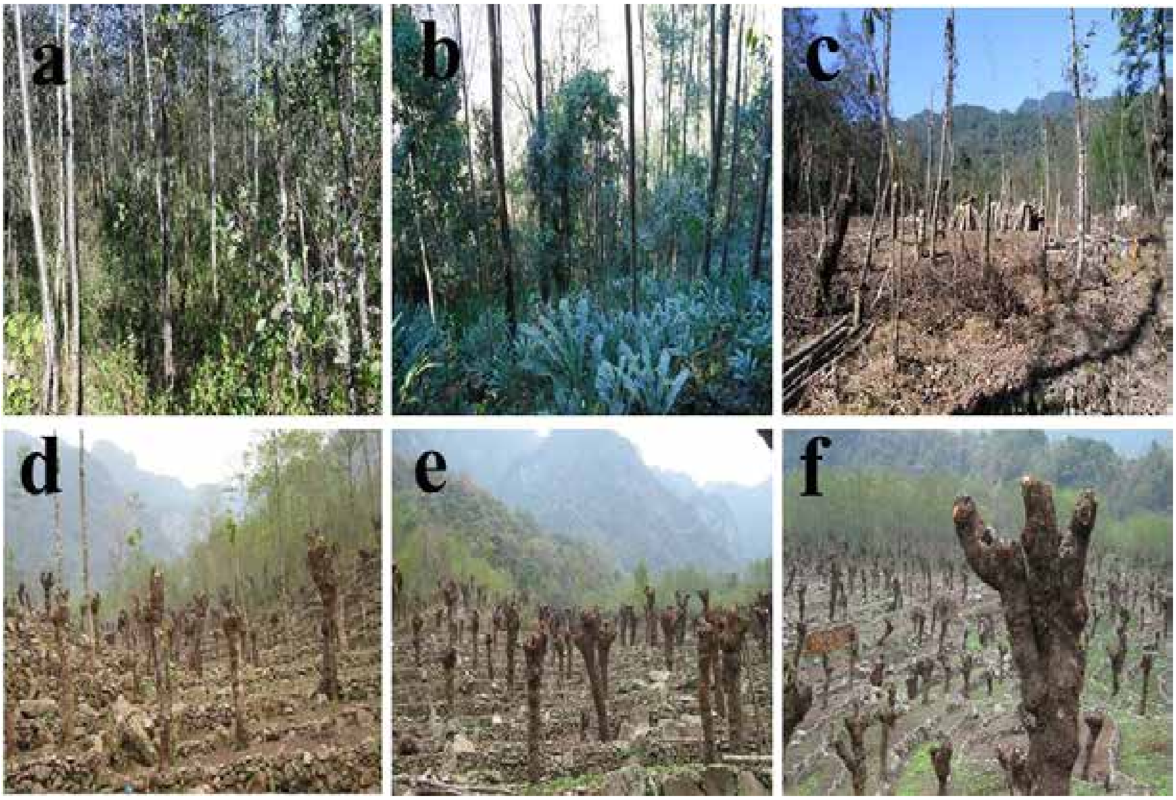

Figure 1: Alder based farming (a) Alder trees, (b) Alder-large cardamom co-cultivation, (c) Pollarding (stage I), (d) Pollarding (stage II), (e) Pollarding (stage III), (f) Pollarding (stage IV)

Amelioration of *jhum* land through Biological Nitrogen Fixation

Biological Nitrogen Fixation (BNF) in *A. nepalensis* takes place through a symbiotic relationship between *Alnus* with nitrogen-fixing actinomycetes of the genus *Frankia* and is therefore able to improve degraded *jhum* lands (Rathore *et al*., 2010). *Frankia* is a genus of soil actinomycetes in the family Frankiaceae that fix nitrogen, both under symbiotic and free-living aerobic conditions, while most rhizobia donot (Benson and Silvester, 1993). BNF and sustainable agriculture are by definition synonymous with sustainability. Systems capable of fixing their own nitrogen exploit their own environment less and may even provide a positive contribution (Kennedy and Tchan, 1992). Long-term sustainability of the agricultural system must rely on the use and effective management of internal resources. The process of BNF offers an economically attractive and ecologically sound means of reducing external nitrogen input and improving the quality and quantity of internal resources (Saikia and Jain, 2007). Actinorhizal plants have the ability to develop an endosymbiosis with the nitrogen-fixing soil actinomycete *Frankia*. The establishment of the symbiotic process results in the formation of root nodules in which *Frankia* provides fixed nitrogen to the host plant in exchange for reduced carbon (Santi *et al*., 2013). Unlike the Rhizobium-legumes symbiosis, where mostly the host plants belong to a single large family, *Frankia* can form root nodules in symbiosis with actinorhizal plants (Baker and Schwintzer, 1990; Benson and Silvester, 1993). The symbiotic relationship between *A. nepalensis* with nitrogen-fixing actinomycetes of the genus *Frankia* has also been recognized by some tribal farmers in Nagaland. Alder based farming is in practice since time immemorial, such that alder trees which are more than 200 years are found in farming areas. The total litter yield of alder depends on the number of plants and amount of N fixed varies between 48.3 kg/ha (60 trees/ha) to 184.8 kg/ha (625 trees/ha). Besides fixing atmospheric N, the litter added to the soil provides phosphorus, potassium, calcium and other nutrients through the addition of biomass (Sharma and Prasad, 1994; Sharma and Singh, 1994; Rathore *et al*., 2010). Agricultural crops, together with alder trees forms a very remunerative agro-forestry system and the ability of the trees to develop and retain soil fertility is a possible promising future if exploited with proper research strategies.

Other economic uses of alder

Alder tree, besides its use in amelioration of *jhum* lands, is also used in a wide spectrum of applications. The foliage is of low to moderate value as fodder for gaur, sheep, goats and other cattle. It serves as a source of firewood and charcoal as it dries easily and burns well. Alder wood has a low calorific value of 18230 kJ/kg. It is also an important source of fiber. In Philippines, kraft pulping of wood of *Alnus* sp. gives a pulp yield of 47.6%, and bleaching improves the brightness to 76%. It is suitable for the manufacture of high-quality paper. The wood is soft, tough, even grained, rather durable, easily sawn, seasons well and does not warp. It is used to a limited extent in carpentry, house construction, tea boxes, for making furniture, rope bridges, splints and matches, poles, furniture parts, turnery and newsprint, although not among the best construction timbers. The wood preserves fairly well but is perishable if subjected to alternately wet and dry conditions. It is also subject to discoloration by oxidation and fungal sap stain. The bark contains about 7% tannin and is used in dyeing and tanning (*Joker,* 2000; *Rathore et al., 2010;* Das *et al*., 2012).

Perspective on Alder-based agroforestry initiatives

In recent times, agroforestry has received more attention due to diversified outputs, sustained agricultural productivity, diverse incomes, moderation in climate aberrations and technological interventions led by research institutions and private organizations (Chavan *et al*., 2015). The intangible benefits often referred to as ecosystem services rendered by the agroforestry systems have been widely recognized by Inter governmental Panel on Climate Change as having potential for sequestering carbon as part of climate change mitigation strategies (Watson *et al*., 2000).These services include micro climate moderation, biodiversity conservation, carbon sequestration, protecting water sources, soil erosion and pollution control. Agroforestry systems have the potential for being an effective tool in climate change mitigation and adaptation steps (Chavan *et al*., 2014).

Keeping in view the significant beneficial role of alder-based farming practices in sustainable agriculture, it is imperative to set in the framework for more research on the multifunctional attributes and ecosystem services of alder-based agroforestry system. Well-evolved agroforestry systems can turn out to be self-sustained production systems without external inputs of fertilizers and pesticides. In addition, this indigenous approach will help to stabilize landslide areas by its deep root system, prevent soil erosion, reforest abandoned *jhum* land, reclamation of wasteland, help in biodiversity conservation, etc.

Conclusion

Nitrogen applied in fertilizers usually provides benefit to plants, but it also has serious disadvantages in causing pollution when applied inefficiently. It is difficult to match nitrogen supply to actual requirements of a crop at a given ecosite and any excess may damage this or other ecosites. The occurrence of significant leaching of nitrate can result into excessive reduction of nitrogen (ammonium) in agricultural or forest ecosystems leading to their acidification through the process of nitrification (Kennedy, 1986). The present 'high input' agriculture is not sustainable. On the other hand, BNF can be a major component in the improvement of agricultural sustainability (Saikia and Jain, 2007). The indigenous alder based farming system holds promising sustainable agricultural models as crops co-cultivated with alder forms a very remunerative agroforestry system through BNF. Though this model may not fix all of shifting cultivation's woes, it surely demonstrates convincingly how this technology can help absorb growing populations and thus divert pressures to clear more forests for agricultural use. Done on a wide scale, this could have a dramatic impact in stabilizing *jhum* cultivation and rehabilitating the damage that has been done by *jhum* degradation (Cairns 2007). Alder based agroforestry, if exploited with proper research strategies, can become a potential farming model on a global scale. In order to replicate this model in lower altitudes where alder trees are not grown, certain research strategies should be developed so as to fully exploit the potential of this indigenous farming model. Research priority should be directed towards identification of superior genotype and mass multiplication for large scale cultivation, *in vitro* regeneration protocol for developing alder trees capable of growing in lower altitudes. Research should also focus on possible application of this model to a wide variety of crops. Also, in-depth research on Alder-*Frankia* symbiotic relationship and their detailed mechanism of nitrogen fixation might reveal new insights towards improving this model. As the above aspects are multidisciplinary in nature, interdisciplinary efforts are needed to unearth and exploit the full potential of this indigenous alder based farming system.

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