to shrinkage of forest cover can affect its breeding cycle.

- One of the major problems with forest area loss is associated with pollination. Species which have fewer pollinators may suffer intensively as shrinking forest areas cannot support adequate pollinator population levels which are essential for forest health. Under these conditions, the species become inbred and lose their genetic variability and vigour.
- It has been predicted that more than 40% of the animal and plant species in Southeast Asia could be wiped out in the 21st century[7]. Most predictions of forest-related biodiversity loss are based on species–area models, with an underlying assumption that as the forest area declines, species diversity will also decline[8].
- It needs to be noted that even small and isolated patches of forest that are created due to loss of forest cover can often be critical for the protection, breeding or migration of some bird species.
- Loss of forest area can lead to an overuse of the remaining forests which will result in canopy opening and consequently significant changes in the forest floor habitat. This situation of open canopy and low density of forests can also affect species like the Asiatic black bear that prefers heavily forested areas as habitat[9].

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COMMENTARY

Chenopodium species: from weeds to a healthy food grain 'quinoa'

Rajendra Prasad and Yashbir Singh Shivay

Genus Chenopodium has about 250 species, which mostly grow as weeds throughout the world. In India, the most common species is Chenopodium album L., which grows as a weed in wheat fields in the north. Its foliage is used as a green vegetable, while the seed is used in the hilly regions for making gruel and mild alcoholic beverages. However, people of Andes, South America have domesticated and developed Chenopodium quinoa (popularly known as quinoa) as an excellent food-grain crop since the past several millennia. Quinoa received global attention in the wake of human intolerance to gluten in wheat resulting in celiac disease, and its demand has largely increased. The United Nations General Assembly declared 2013 as the International Year of Quinoa. The leading country in the world producing quinoa is Peru, followed by Bolivia. However, considering the demand and high market prices, a number of countries, including India have started growing quinoa. However, farmers in India are facing problem in marketing the crop, because there is no local consumption and exporting a farm product is problematic. India has a variety of food grains, including pearl millet, sorghum and several minor millets to tackle gluten intolerance and celiac disease.

The genus *Chenopodium* belongs to the family Amaranthaceae, which includes former family Chenopodiaceae and contains about 165 genera and 2040 species[1]. Amaranthaceae is a widespread cosmopolitan family and is spread from the tropics to cool temperate regions, whereas Chenopodiaceae had its centres of diversity in dry temperate and warm temperate areas[2]. Genus *Chenopodium* has a worldwide distribution and contains about 250 species[3]; 21 species have been reported in India[4]. The most widespread species in the Indian subcontinent is *Chenopodium album* L., a common weed in wheat fields in northern India[5], Bangladesh[6] and Pakistan[7], it is popularly known as bathua in Hindi. Other reported *Chenopodium* weed species in India include *C. ambrosioidas*, *C. murale*, *C. opulifolium* and *C. botrys*[8]. *C. album* grows as a weed all over India and some names in other Indian languages include: *chakvit* (Konkani), *vastuccira*

Table 1. The 1000-grain weight and crude protein content in *Chenopodium album* vis-à-vis other food grains

Species	1000-grain weight (g)	Protein (%)
Bathua (*Chenopodium album*)	0.59–0.94 (one cultivar recorded 2.24) (ref. 11)	13.49–16.27 (ref. 11)
Quinoa (*Chenopodium quinova*)	2.88–3.00 (ref. 13)	14–16 (ref. 13)
Buckwheat		
Fagopyrum esculentum	12.0–60.0 (ref. 14)	10.1 (ref. 14)
Fagopyrum tartaricum		14.3 (ref. 15)
Barnyard millet (*Echinochloa esculenta*)	3.76 (ref. 16)	6.79–13.09 (ref. 17)
Little millet (*Panicum sumartense*)	3.17 (ref. 16)	7.96–10.66 (ref. 17)
Kodo millet (*Paspalum scorbiculatum*)	6.74 (ref. 16)	6.50–10.66 (ref. 17)
Finger millet (*Eleucine coracana*)	3.23 (ref. 16)	5.27–6.44 (ref. 17)
Foxtail millet (*Setaria italica*)	3.35 (ref. 16)	13.10 (ref. 17)
Pearl millet (*Pennisetum glaucum*)	12.25 (ref. 16)	10.6 (ref. 18)
Sorghum (*Sorghum bicolor*)	31.01 (ref. 16)	3.25–14.9 (ref. 19)
Rice – basmati (*Oryza sativa*)	21.1–22.7 (ref. 20)	7.7–8.9 (ref. 20)
Wheat – spring (*Triticum aestivum*)	37.1–42.3 (ref. 21)	10.3–12.9 (ref. 21)
Oats	30–40	11.0–15.0 (ref. 22)

(Malyalam), *paruppukkirai* (Tamil) and *pappukura* (Telugu)[9]. The common English names are goosefoot and lambs quarters. Bathua has been used in India as green vegetable and for stuffing parathas (layered bread) in north India since ages. The leaves of *C. album* are rich in protein (2.6–6.4%), carotenoids (78–190 mg kg^{-1}) and vitamin C (0.5–2.5 mg kg^{-1})[10]. Its flour mixed with wheat flour can be used for making chapatis and when mixed with gram (*Cicer arietinum*) flour, it can be used for making sweets, such as laddoos[11]. In Himachal Pradesh, its grain is used for making a gruel-type dish called phambra or laafi and for making mildly alcoholic beverages such as soora or ghanti[12]. *C. album* has also been used in Ayurvedic and local medicines in India as a blood purifier, hepato-protective, laxative, diuretic, sedative and anthelmintic against round and hook worms[9]. However, *C. album* could not emerge as a food grain crop, since the Himalayas provided wide biodiversity and it had to compete with buckwheat (*Fagopyrum esculentum*) and a number of small millets, including barnyard millet (*Echinochloa crusgalli*), proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scorbiculatum*) and foxtail millet (*Setaria italica*), which have larger grain size (Table 1)[11,13–22], one of the criteria used by ancient humans in domesticating plant species[23].

However, people of Andes, South America (Peru, Bolivia, Ecuador, Venezuela, Colombia, Chile and Argentina) domesticated quinoa (*Chenopodium quinoa* Wild) around 3000–4000 years ago and made it a successful grain crop. Quinoa has been an important staple in the Andean culture; the plant was indigenous and relatively obscure to the rest of the world[24]. The Incas referred to it as chisoya mama or 'mother of all grains', and the Inca emperors used to traditionally sow the first seeds of the season using 'golden implements'[25]. During the Spanish conquest of South America, the colonists considered quinoa as being related to the religion and culture of the Andes people and forbade its cultivation; the Incas were forced to grow wheat instead[26]. The United Nations General Assembly declared 2013 as the 'International Year of Quinoa' in recognition of the ancestral practices of the Andean people, who have preserved it as a food for present and future generations[27]. Quinoa gained international importance in the beginning of the 21st century in the light of gluten intolerance in people and prevalence of celiac disease[28,29] reported from USA[30], Canada[31], Europe[32], Sahara[28] and even India[33,34]. About 1% of the world's population is reported to be affected by celiac disease[35]. Gluten is found in wheat, barley and rye[36], while oat varieties differ in their gluten content and some of them can be well tolerated[37]. The classic symptoms of celiac disease are diarrhoea, gas, bloating and fatigue, and associated symptoms include low blood count (anaemia) and osteoporosis. It is more frequent among infants and children below 2 years of age[29], but adults also suffer and sometimes there are no obvious symptoms. Quinoa has 14–16% protein compared to 10.3–12.9% in wheat (Table 1); it has no gluten and has therefore been considered as the most healthy food grain. Quinoa has also a glycaemic index of ~53 compared to ~75 for white wheat bread and ~72 for white boiled rice[38]. The glycaemic index is a value assigned to foods based on how slowly or how quickly they cause increase in blood glucose levels. Relatively low glycaemic index and high protein make quinoa the choice food grain for diabetics.

Peru is the leading country in the world in quinoa production. In 2014, it produced 114.3 thousand metric tonnes (TT) of the crop, followed by Bolivia (77.4 TT) and Ecuador (0.8 TT) (World Atlas.Com). Production in Peru increased from 22.3 TT in 2001 to 114.3 TT in 2014 due to high prices in European markets (11.6 US$ kg^{-1}) as against the farm price of US$ 1.17 kg^{-1} in Peru[39]. Due to increased demand in USA, Canada and Europe, cultivation of quinoa has started in several countries in the world, including India[40]. In India, it is being cultivated in Rajasthan, Uttarakhand and Andhra Pradesh, but farmers are facing the problem of lack of local consumption[41]. This is because adequate steps were not taken by the government or traders for proper procurement and export. It is not easy to enter international food grain market, because there are strict quality requirements and India is yet to have standard food quality laboratories. At least one food quality laboratory is needed in each state in the country, where farmers and traders can get their products tested for nutritional components such as proteins, including specific amino acids, carbohydrates, fibre, vitamins, minerals, etc. Most agricultural produce is sold in India on the basis of appearance, size and colour.

Quinoa is not likely to be accepted as a food grain in India, because there are a variety of food crops such as pearl millet, sorghum and several minor millets[17], which can meet the nutritional needs of people and can easily overcome the celiac disease problem which is generally

reported from the wheat-consuming North India[33]. In fact, the 'green revolution', which in reality is the 'wheat revolution', has adversely affected the area under millets and sorghum. Wheat production in India has increased from 6.0 million metric tonnes (MT) in 1950–51 to 93.5 MT in 2015–16, while the area under wheat increased from 10 to 30 million hectares during the same period[42]. Wheat is also being procured at a pre-announced price, and is procured and distributed throughout India through the Public Distribution System by the Government at subsidized prices to people living below poverty line. However, from the food and nutritional security point of view, cultivation of minor millets, pearl millet and sorghum has to be continued in their niche areas with better varieties and improved production technology. A reasonable profit to growers of these crops needs to be assured by suitable government policies. Thus, as rightly pointed out by Swaminathan and Bhavani[43], by mainstreaming ecological considerations in agricultural technology development and dissemination, India can enter an era of 'evergreen revolution' and sustainable food and nutritional security.

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