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Ethnobotanical profile of *Croton macrostachyus* (Euphorbiaceae) in Ethiopia: Review of the literature

Getu Alemayehu
Jigjiga University, College of Natural Sciences, Department of Plant Biology, Jigjiga, Ethiopia

Abstract
The principal aim of the paper is to review existing literature sources on available ethnobotanical information of the species, to identify existing gaps in research and information to assist in the proper utilization, management, and conservation of plants. *Croton macrostachyus* Hochst. Ex Del. is commonly known as rushfoil or broad-leaved croton (English). A deciduous tree belongs to the family Euphorbiaceae. It has a rounded crown with slender trunk and massive spreading branches. The leaves are simple and broadly ovate, green, turning to orange before falling, base rounded. Fruits green when young, turning grey at maturity, pea-sized with three lobed capsules. It is found in a wide range of ecological areas including forest margins, roadsides, in moist lowlands, in soils of volcanic origin, both dry and moist midlands, and highlands areas in almost all the flora regions of Ethiopia. The plant is native to Ethiopia, Eritrea, Kenya, Nigeria, Tanzania, and Uganda and it occur in other sub-Saharan countries (esp. in Guinea, Angola, Zambia, Malawi, and Mozambique. *Croton macrostachyus* has compounds isolated from its root; fruit and bark includes cyclohexane diepoxides, crotepoxide, diterpenoids, crotomacrine, Lupeol, Neoclerodanen, and trachylobane. *Croton macrostachyus* has a medicinal value for treatment of malaria, headache, skin rash, internal worms, abdominal pain, rabies, ringworm infestation, hemorrhoids, ascarasis, and sexually transmitted diseases. The fruits and a decoction of the roots are used as e medicine against venereal diseases and seeds are used to abuse abortion. The pulverized bark mixed with KOSSO (Hagenia abyssinica, Rosaceae) is a very effective purgative and vermifuge. The farmers especially in Hararghe and Shoa used to protect stored grain from pests. The flowers are heavily scented and used for bee forage. *Croton macrostachyus* is one of the plant species used for the smoking and cleaning of milking and fermenting utensils. The wood has a domestic use to make tool handles, small stools, boxes, farm implements, mortare and pistile. The wood is used as fuel that burns even when green, but with a rather unpleasant spicy odor and much smoke; it is also used to make charcoal. The leaves are used as green manure. *Croton macrostachyus* can be lopped, pollarded or coppiced. It has a long taproot and numerous side-roots, which makes it adapted to dry climates. It is widely used and adapted to local conditions.

Keywords: bee forage, *Croton macrostachyus*, fuel, green manure, medicinal value, pesticide

Introduction
Plants are invaluable and fundamental to almost all life on earth. They provide wide range of uses to human beings such as medicine, food, shelter, clothing, fuel wood for cooking, timber for construction, utensils, as well as fodder for cattle. They also recycle essential nutrients of ecosystems, establishing soils and maintaining soil fertility in addition to protecting areas of water catchments. Moreover, they keep ecological and climatic balance, facilitate, and control rainfall through the process of evaporative transpiration. All our food comes from plants either directly or indirectly. Plants have played a significant role in maintaining human health and improving the quality of human life for thousands of years. The rural people live in the area where plants are naturally growing have remarkable knowledge of the uses of plants growing around them. Their livelihood depends on plant availability and their plant use knowledge, which they gain from their previous generation. However, without proper documentation this information may be lost forever. Therefore, ethnobotany has great importance for systemic recording and documentation of indigenous knowledge of plant use, management and other aspects in relation with culture before their extinction.

Ethnobotany studies concerning plants, which describe local people's interaction with the natural environment, uses and other relations that exist between humans and plants (Martin, 1995; Cotton, 1996) [69, 21]. It tries to find out how people have traditionally used and are still using plant resources. The focus of ethnobotany is on how plants have been or are used, managed and perceived by human societies. These relationships can be social, economic, symbolic, religious, commercial and artistic (Aumeeruddy and Pie, 2003) [10]. Ethnobotanical studies can explore the uses and management of the species and the associated indigenous knowledge. It is necessary that we should have full knowledge regarding the occurrence, distribution, local uses and management of these ethnobotanically valued plants for their proper utilization. The conservation of ethnobotanical knowledge as part of living cultural knowledge and practices between communities and the environment is essential for biodiversity conservation (Martin, 1995; Cotton, 1996; Balick and Cox, 1996) [69, 21, 15].

Croton macrostachyus has several ethnobotanical uses in addition to maintaining ecological balance by providing various ecosystem services. *Croton macrostachyus* has a medicinal value for treatment several diseases. The farmers especially in Hararghe and Shoa used to protect stored grain from pests. The flowers are heavily scented and used for bee forage. It is one of the plant species used for the smoking and

cleaning of milking and fermenting utensils. It has a domestic use to make tool handles, small stools and boxes. The leaves are used as green manure.

Most of the previous studies were not focused on specific uses and management of the species. Thus, saving the species, documenting and preserving indigenous knowledge is essential. For this reason, this review is initiated to gather record and document indigenous knowledge of the species. Over-harvesting can threaten the species. Without management intervention, it may lead to the extinction of a species and loss of associated indigenous knowledge on use and management.

Ethnotaxonomy of *Croton macrostachyus*

Croton macrostachyus is commonly known as rush foil or broad-leaved *Croton* (English). A deciduous tree belongs to the family Euphorbiaceae, a very large family with 300 genera and 8,000 to 10,000 species. The name of the genus *Croton* comes from a Greek word *Kroton,* which means ticks, because of the seeds' resemblance to ticks (Berry, 2000) [17]. The specific epithet is from the Greek macro- (large) and –stachyus (relating to a spike) hence "with a large spike". The genus contains over 1,200 species, which are distributed throughout the world (Berry, 2000) [17]. Eight of these species (*C. dichogamus, C. zambesicus, C. menyhartii, C. somalense, C. schimperianus, C. sylvaticus, C. lobatus*, and *C. macrostachyus*) are found in Ethiopia (Gilbert, 1995) [38]. There is still no one language that all the people of Ethiopia have in common. The species has different vernacular names in different part of Ethiopia (Table.1)

Table 1: The vernacular names of the species in some of local languages.

No	Vernacular name	Language	Source
1	Kombelit	Meinit ethinic groups	Mirutse Giday, 2007 [76]
2	Wush, Masincho	Somalinya	(Brei Breitenbach, 1963; Azene Bekele, 1993; Gilbert, 1995 [19, 11, 38]
3	Mekenissa	Guragenya	Breitenbach, 1963; Azene Bekele *et al.*, 1993; Gilbert, 1995 [19, 11, 38]
4	Tambuk, Ambuk, Berberi_Islami	Tigrinya	Breitenbach, 1963; Azene Bekele *et al.*, 1993; Gilbert, 1995; Wolde Michael Kelecha, 1977 [19, 11, 38, 116]
5	Dogma	Orominya in Welega	Wolde Michael Kelecha, 1977 [116]
6	Mekenisa	Orominya in Welo	Wolde Michael Kelecha, 1977 [116]
7	ANKOWA	Orominya in Borena	Wolde Michael Kelecha, 1977 [116]
8	Alele	Oromigna	Wolde Michael Kelecha, 1977 [116]
9	Masincho, Wush	Orominya in Sidama	Wolde Michael Kelecha, 1977 [116]
10	Mesina	Hadyinya	Wolde Michael Kelecha, 1977 [116]
11	Wago, Mekel	Kefinya	Wolde Michael Kelecha, 1977 [116]
12	Mesena	Kembatiyna	Wolde Michael Kelecha, 1977 [116]
13	Bisana	Amharinya	Wolde Michael Kelecha, 1977; Azene Bekele, 1993; Gilbert, 1995 [116, 11, 38]
14	Woshu	Gimirigna	Azene Bekele *et al.*,1993; Gilbert, 1995 [11, 38]
15	Masaganta	Konssoinya	Wolde Michael Kelecha, 1977 [116]"

As we see here, having several local names in different local language of Ethiopia may indicate the importance of the species. *Croton macrostachyus* has a rounded crown with slender trunk and massive spreading branches (Fig.1a). The leaves are simple and broadly ovate, green, turning to orange before falling, base rounded (Fig.1b). The bark color of the species ranges from green through light gray to pale-brown. The bark is smooth when young and slightly fissured longitudinally on aging. The height of the plant more commonly ranges from 7 to 15 meters in the open ground or in open areas; it is a small tree, it can grow up to 25 meters when growing close to one another or with other forest species (i.e. when competing for light) but the diameter of the bole becomes thinner and straight (Dechasa Jiru, 1999) [24]. Its flowers are yellow-white, normally dioeciously or at least on a separate shoot (Breitenbach, 1963; Friis, 1992) [19, 34]. Inflorescence of *C. macrostachyus* is usually a terminal raceme that can range from 15 to 32 cm long with strongly sweet scented flowers. The inflorescence consists of creamy-whitish to yellow flowers, which are fragrant and decorative (Fig.1c). The flower spike turns down as fruits mature and become heavy.

Fruits green when young, turning grey at maturity, pea-sized with three lobed capsules (Fig.1d), when mature, each fruit splitting open *to* release three shiny grey seeds (Fig.1f).

(a) Rounded crown


(b) Leaf shape and petiole


(c) Flowering branch

(d) Fruit not matured (e) Matured fruit (f) Seeds

Fig 1(a-f): Vegetative and reproductive part of *Croton macrostachyus*

Ecological and geographical distribution

It is found in a wide range of ecological areas including forest margins, roadsides, in moist lowlands, in soils of volcanic origin, both dry and moist midlands, and highlands areas in almost all the flora regions of Ethiopia (Azene Bekele *et al.*, 1993; Fichtl and Admassu Adi, 1994; Gilbert, 1995) [11, 31, 38]. *Croton macrostachyus* occurs as a pioneer species commonly on degraded mountain slopes, on disturbed areas, in borders of cultivated fields, on waste ground, along river habitats. It occurs in dry, moist and wet Weynadega and Dega as well as in upper altitudes of Dry Kolla agro climatic zones in Tigray, Gondar, Gojam, Wollo, Bale, Shoa, Illubabor, Kefa, Sidamo and Hararge floristic region at altitudes between 1,100 and 2,500 m. a. s. l. It is associated with Juniperus-Podocarpus habitats and occurs in the warmer parts of the montane rain forests and semi-tropical rain forests. Outside the forests, in wetter areas, the species is widely distributed. It is often known for invading abandoned cultivations (Friis, 1992) [34]. The plant is native to Ethiopia, Eritrea, Kenya, Nigeria, Tanzania and Uganda (Hedberg *et al.*, 1995; Schmelzer and Gurib-Fakim, 2008) [41, 94]. It occurs in other sub-Saharan countries (esp. in Guinea, Angola, Zambia, Malawi, and Mozambique (Fichtl and Admassu Adi, 1994; Gilbert, 1995) [31, 38]. C. macrostachyus is the most numerous in the tropics (Shukla and Misra, 1979; Heywood, 1993) [96, 42]. It occurs in Northeast tropical Africa, East tropical Africa, west central tropical Africa, South tropical Africa, and Madagascar (Figure. 2).

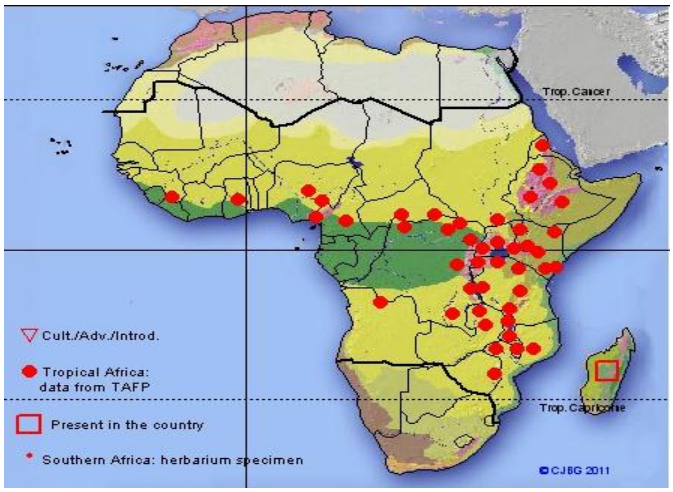

Fig 2: Distribution of *C. macrostachyus* in Tropical Africa and Western Indian Ocean (Madagascar)

Chemical and pharmacological studies

The individual chemicals from which plants made are phytochemicals. Phytochemical study of plants is great importance in developing drugs (Kaufman *et al.*, 1999) [53]. Drugs are strictly defined as chemical substances that are used to prevent or cure diseases in humans, animals and plants. Drugs from natural products are secondary metabolites and their derivatives (Thomas, 2000) [105]. Natural products have been a major source of drugs for centuries, with more than 25% of the pharmaceuticals in use today derived from natural products (William *et al.*, 2002) [114]. The natural products as medicinal agents presumably predate the earliest recorded history as the earliest humans used various, but specific plants to treat illness. Natural products are those chemical compounds derived from living organisms, plants, and animals. The secondary metabolites of organisms, including plants, serve important biological and ecological roles, mainly as chemical messengers and for defense purposes (Sarker *et al.*, 2006) [93]. Phytochemical studies on the genus *Croton* has lead to the isolation and characterization of different classes of secondary metabolites. Terpenes, flavonoids, and alkaloids have been isolated from different *croton* species (Zelalem Yibralign, 2007) [125]. The terpenes are ubiquitous metabolites found in all living organisms. They include essential metabolites such as the sterols acting as membrane stabilizers in eukaryotes or precursors for steroid hormones. They are

among the most widespread and chemically diverse groups of natural products throughout the plant and animal kingdom (Kaufman *et al.,* 1999) [53]. The seeds of *Croton macrostachyus* contain about 19% oil, which is a slightly viscous, yellow-orange fluid and slightly vesicant. The seeds also contain several saponins and a resin, which is said to be more toxic to insects. Previous studies revealed existence of a number of Terpenes isolated from *Croton macrostachyus* (Table 2).

Table 2: Some Terpenes isolated from *Croton macrostachyus*

NO.	Name of the compound	Part of the plant used	Source
1	Crotomacrine, *Trachyloban* and *Neoclerodanen.*	Fruits	-Kapingu, *et al.,* 2000 [50]
2	Crotepoxide	Fruits	-*Addae*- Mensah *et al.,* 1992; Kupchan, *et al.,* 1968 and Kupchan, *et al.,* 1989 [5, 60, 59]
3	*Diterpenoids*	Root	-Kapingu, *et al.,* 2000[50]
4	Crotin (a chalcone), proteins, fatty acids, saponins, resins and alkaloids	Root	-Schmelzer and Gurib-Fakim, 2008; Salatino *et al.,* 2007 [94, 92]
5	Cyclohexane diepoxides	Root, Fruit, Bark	-Kupchan, *et al.,* 1968 and Kupchan, *et al.,* 1989 [60, 59]
6	Lupeol (a triperpene)	Root, Bark	-Schmelzer and Gurib-Fakim, 2008; Salatino *et al.,* 2007 [94, 92]
7	-Lupeol and betulin	Stem bark	-*Addae*-Mensah *et al.,* 1992 [5]

Ecological Uses

Croton macrostachyus prevents soil erosion and environmental degradation through its canopy that holds the water for some time and drop it slowly. As the proportion of the canopy increases, water infiltration increases and surface runoff decreases resulting in more water in the soil. The result is increased water availability and greater volume and discharge to springs, and decreases in the effective length of the dry season similar to other indigenous tree species such as *Podocarpus falcatus* and *Ficus spp*. (Legesse Negash, 1995) [62]. *C. macrostachyus* produce extensive lateral roots to hold the soil; it may be a good candidate for planting on hillsides where erosion is a problem. Due to its drought hardiness and fast growth, *Croton macrostachyus* is considered useful for a forestation of shifting sand dunes, degraded wasteland, hill slopes. The species is recommended for planting in soil and water conservation measures (Azene Bekele *et al.*, 1993; Gilbert, 1995) [11, 38].

Indigenous plants have multipurpose uses and indigenous people have ethnobotanical knowledge of their use and management. Indigenous species are ecologically more valuable than exotics for the conservation of native flora and fauna as well as for the conservation of water (Legesse Negash, 2007) [63]. *Croton macrostachyus* is one of Indigenous tree species of Ethiopia. It is widely used and adapted to local conditions (EFAP, 1994; Legesse Negash, 1995; Tadesse Hailu *et al.*, 2000) [26, 62, 99]. *C. macrostachyus* is a very competitive and densely canopied dry deciduous plant.

Medicinal use

Croton macrostachyus is one of the main traditional medicines serves to cure different diseases for human being and domestic animals. It has medicinal uses for various skin diseases, management of helminthes and venereal diseases, and to induce abortion (Amare Getahun, 1976; Gelahun Abate, 1989; Schmelzer and Gurib-Fakim, 2008) [8, 35, 94]. The plant is used for the treatment of malaria (Fisseha Mesfin *et al.*, 2009; Mirutse Giday *et al.,* 2007) [33, 76], abdominal pain (Giday Yirga *et al.*, 2011) [18], wounds, ringworm infestation, hemmorhoids (Aberra Geyid, 2002; Worku Abebe, 1986) [4, 117] and as a purgative in cases of ascariasis (Worku Abebe, 1986; Mazzanti et *al*., 1987; Kloos, 1977) [117, 70, 56]. Fisseha Mesfin *et al.* (2009) [33] documented that people of Wonago Wereda use the plant for treatment of Diarrhea and Epilepsy. Similarly, Nigussie Amsalu (2010) [82] reported the local people of Farta wereda used to treat ringworm, heart disease jaundice, elephantiasis, gonorrhea and tuberculosis.

The bark mixed with KOSSO (*Hagenia abyssinica*, Rosaceae) is a very effective purgative and vermifuge. The bark of *C. macrostachyus also is* used for treatment of tapeworm infection, syphilis in humans (Dessalegn Dessisa et *al*., 2001) [25]. Bark from stems and roots is boiled in water and newly born babies are bathed in the mixture as a remedy for skin rash. The sap is used as a common curative traditional medicine for fungal skin diseases (Dechasa Jiru, 1999) [24]. The stem bark and the tips of the different branches of the tree are used for the treatment of malaria and hepatitis in different parts of Ethiopia, particularly in Gojjam in the Amhara Regional State (Zelalem Yibralign, 2007) [125].

The seed is used by local population of the Bonga area of South Ethiopia for treatment of tapeworm infection in human (Styles *et al.,* 1989) [98]. The crude ground seeds of *C. macrostachyus* showed high molluscidal activity (Dawit Abebe and Ahadu Ayehu, 1993; Kupchan *et al.*, 1968 and Kupchan *et al.,* 1989; *Addae*-Mensah *et al.,* 1992) [5, 23, 60, 59].

The root is chewed to treat toothache. According to Mirutse Giday (2007) [76], Meinit ethnic groups use its root for the treatment of snakebite. Ripe crushed fruits mixed with butter or honey and ground leaves are applied to skin diseases. The fruits and a decoction of the roots are used as a medicine against venereal diseases. The decoction from the young shoots and leaves mixed with Sensel (*Justicia schimperiana, Acanthaceae)* is used to treat jaundice.

A recent report by Karunamoorthi and Ilango (2010) [51] showed Larvicidal activity of *Croton macrostachyus* against *Anopheles arabiensis* Patton (a potent malaria vector). Its crude extract was found to demonstrate high activity against reference strain of *Neisseria gonorrhoeae* and mutagenic activity on human lymphocytes and mice spleen lymphocyts (Aberra Geyid, 2002; Mesfin Tefera, 2006; Mesfin Tefera *et*

al., 2010) [4, 72, 73]. A report by Taniguchi and Kubo (1993) [102] indicated antimicrobial and antifungal activities of methanol and dichloromethane extracts of the leaves and stem of *Croton macrostachyus*. Recent reports also indicated that essential oils from *Croton macrostachyus* possess antibacterial activities (Getachew Belay *et al.,* 2011; Biruhalem Taye, *et al.,* 2011) [36, 18] and antileishmanial activities (Yinebeb Tariku, 2008; Yinebeb Tariku *et al.,* 2010) [121, 122]. The oils that obtained from berries of the plant with antileishmanial activities have high efficacy (Habtamu Gelaw *et al.,* 2012) [40]. Boiled leaf decoction is drunk or ashes taken orally as treatment for cough; juice from fresh leaves is applied on wounds to hasten clotting. Moa Megersa (2010) [77] documented that people of Wayu Tuka Wereda, uses its juvenile leaves to treat ringworm.

Uses as pesticides for grain storage

The high costs and the erratic supply of chemical pesticides in developing countries have stimulated a renewed interest in traditional botanical pest control agents (Abate Bekele *et al.,* 1996) [1]. In Ethiopia, (Lynch *et al.,* 1986) [66] mentioned *Datura stramonium* and *Phytolacca dodecandra,* as plants with pesticidal effects, which are used by farmers to protect stored grains. Yemane Kidane and Yilma Habteyes (1989) [118] added chili pepper (*Capsicum sp*.) and *Croton macrostachyus is* to the list of local plants used to protect grains in the storage.

According to Aberham and Abate Bekele (2002) [3], *Croton macrostachyus is* one of the local plants of Hararghe and Shoa, used by farmers as natural pesticide to protect their stored maize and sorghum. Practically all farmers put leaves of the local plants, which are assumed to have a protective effect against insects, between grain layers and on top.

Croton macrostachyus has pesticide equalities, which is very common in Hararghe and *Shoa*. Farmers find it difficult to use the chemicals suggested by the extension service for post-harvest pest control. Instead, farmers use more local plants (*Euphorbia tirucalli, Schinus molle, Croton macrostachyus, Eucalyptus globlus and Phytolacca dodecandra)* as traditional pesticides. The types of plants used can differ from region to region, only few of the plants utilized in Hararghe are also used in Shoa, and vice versa. According to Talemos Seta *et al.* (2013) [101], in Wolayta Zone several preservation methods are involved to store seeds and tubers for future use where its shortage occurs. For example, maize and sorghum are kept for future use by smoking and thorough mixing with ash, animal dung, or powders from *C. macrostachyus.*

Source of nectar for honey bee

The botanic origin of honey is one of the most important parameters of honey quality (Tucak *et al.,* 1998; 2000 and 2004) [107, 108, 106]. The quality of honey depends on the plants that bees use in their nourishments. The honey obtained from different plants has different characteristics and applications, both in medicine and food industries. The basic foods of each honeybee colony are nectar and pollen (Crane, 1999; Weidenmuller and Tautz, 2002) [22, 112]. Nectar is transformed into honey. Pollen and honey are stored in the hive for future use. Human has exploited these substances for millions of years (Crane, 1999) [22]. Honey and pollen production depends mainly on abundance of some plant species and their attractiveness to honey bee (Williams and Carreck, 1994; Segeren *et al.,* 1996) [81, 115, 95]. Thus, the sustainable beekeeping in a given region needs detailed knowledge of the bee plants, which grow in the environment of the hives (Segeren *et al.,* 1996; Riedacker, 1996; Bakenga *et al.,* 2000) [95, 89, 14].

The showy light-yellow flowers of *Croton macrostachyus*, together with their fragrance, are attractive to honeybees used for bee foraging. Consequently, the species is an important source of honey. It flowers from April to July, which makes the tree a very important source of honey as it flowers profusely when most annual honeybee plants cease flowering. *C. macrostachyus* experience extended flowering seasons in most areas, peaking in March-June and May-July, providing excellent beeforage. This exceptional flowering phenology makes the species the most important in ensuring sustainable honey production in areas where the species dominate the landscape. Honeybees collect both pollen and nectar from flowers (Fichtl and Admassu Adi, 1994; Dechasa Jiru, 1999; Asfaw Debela *et al.,* 2003) [31, 24, 9]. An aromatic brownish honey is harvested from this species. Therefore, *C. macrostachyus* has a great potential for sustainable beekeeping. The collection of nectar and pollen of C. macrostachyus by *Apis milfera adonsonii* has been noted in Ethiopia (Fichtl and Admasu Adi, 1994) [31]. *C. macrostachyus* is highly nectariferous bee plants, it could be cultivated and protected to increase honey production. *Croton macrostachyus*, is one of a tree suited for a beekeeping enterprise. The numerous branches of the large trees of the species are used by traditional beekeepers for keeping many traditional beehives both in the forest and at the backyard.

Treating milk for palatability and preservation

Milk is a major source of food, especially for pastoralist people. However, it is also one of the most perishable foodstuffs and requires processing, both to improve the palatability and to preserve for use later. In Ethiopia with this background, the farmers were using locally available preservatives and their indigenous methods of preservation. According to Fikerineh Negash *et al.* (2012) [32], presently farmers use several tree species for milk treatment. *Croton macrostachyus* is one of the plant species used for the cleaning of milking and fermenting utensils. However, cleaning plants differ from place to place and even from household to household based upon preferences (Lemma Fita, 2004) [64]. *Croton macrostachyus is used* for the smoking of milking and fermenting equipments. Mogessie Ashenafi (1994) [78] also mentioned the smoking of fermenting vessels with *Croton macrostachyus* wood by pastoralists in rural areas is more common. The local people used these plants for smoking of utensils to give the product good flavor and aroma, to increase shelf life of the milk and since it is the tradition of the society. The report of Tesfaye Mengistie (2007) [103] stated that nearly all inhabitants of Metema district were smoked milk vessels as a traditional preservative method to improve the taste and quality of milk and milk products. Kassaye Tari *et al.* (1991) [52] also reported on the use of smoke to prepare the storage gourds for the preparation of concentrated, fermented milk by pastoralists in Southern

Ethiopia.

According to Fikerineh Negash *et al.* (2012) [32], the majority of the farmers in both rural and urban production systems were processing milk for several reasons, for home consumption, for marketing, to increase shelf life of the product, due to surplus production of milk and to diversify products, respectively. Similarly Lemma Fita (2004) [64], reported that milk was processed in order to increase the family income through sale, diversify the products for consumption and to increase the shelf life of the products as marketing is limited once a week due to the need to travel to long distance to reach market places. In both systems, fermented milk/yoghurt-like sour milk (ERGO) traditional butter (KIBE), buttermilk (ARRERA), cottage cheese (AYIBE), and whey (AGUAT) are produced. Milk has to be fermented before it to be processed to further products. Farmers prefer to ferment and process milk from local cows due to its high fat content. Fermentation preserves the high quality of nutrients present in milk in a relatively more stable form Mogessie Ashenafi (1996) [79] could be another reason.

Similarly, in Kenya several tree species are used for the preservation of milk for the production of *mursik*, a traditional technology developed and widely used by various pastoral groups. *Mllrsik* is the Kalenjin term for fermented milk, but the term is recognized and used by all ethnic groups in the research area. Preserving milk practiced in Kenya, paying particular attention to the initiation and preparation of the milk storage gourds. The technology, however, is not restricted to Kenya, but is widely used in other Africa countries as well, for example the Sudan (Abdelgadir *et al.*, 1998) [2], Zimbabwe (Feresu, 1992) [29], Tanzania (Isono *et al.*, 1994) [43] and Ethiopia (Mogessie Ashenafi, 1994) [78]. The charcoal crushed into the gourd keeps it from wearing out fast, and it erases the natural smell of a gourd when milk is drunk from it. According to Ronoh (1987) [90], the methods used to preserve milk by the Maasai, Kalenjins, Boranas, Turkanas, Pokot and Somalis are such that milk can be kept as long as three months.

Other ethnobotanical uses

Raw materials from the forest are used to make a wide range of products, while substitutes for many items are available in larger towns, in most villages people still rely almost exclusively on materials from forests and woodlands for domestic items. Many different species are used to make tools and utensils that meet day- to- day household needs stirring sticks, pestle, mortar, spoon, axe handle, hoe handle, and spade handle. A proper tool handle is one of the basic requirements for the safety and high productivity of forest workers. Several forest tools have wooden and metallic parts. Substantial amount of work has been done throughout the world to design tool handles, which fulfill the agronomical and physical requirements of the job. *Croton macrostachyuse is one of* locally available hard and softwood among the commonly utilized species. The wood of *C. macrostachyus* is very soft, light (density 0.499), fine-textured and cream-colored. However, it is very strong and tough and hence suitable for indoor carpentry, farm implements, ordinary furniture, boxes, tool handles, and inner layer of play wood (Breitenbach, 1963) [19]. In most rural areas the scarcity of other forest trees due to forest destruction has led to the increased cuttings of *C macrostachyus* for construction, use as farm implements such as *KEMBER*, (Fig.3a) and traditional pestle and mortars (Kebebew Wakjira, 2007) [54], (Fig.3b).

Table 3: Material culture derived from *Croton macrostachyus* with English and local name

No	Category of materials	Name of material in English	Local Name (Language)	Source
1	Farm implements	Tradational Plough share called Yoke	Kember	Breitenbach, 1963; Kebebew Wakjira, 2007 [19, 54]
2	Household utensils	▪ Mortare ▪ Pistile	Mukecha Zenezena	Breitenbach, 1963; Kebebew Wakjira, 2007 [19, 54]
		Stirring Stick	Mamasaya	Breitenbach, 1963 [19]
		▪ Axe handle ▪ Spade handle	Ejeta	Breitenbach, 1963; Kebebew Wakjira, 2007 [19, 54].
		▪ Small stool ▪ Boxes	Kurce Saten	Personal observation
3	Preparation of malt (*bikil*)	Wrapping of Malt	Yebikil Metekleya	Personal observation

The other use for *C macrostachyus* is the production of building and furniture. In most rural areas, plants are still the main sources of supply materials for constructing houses, and fences. Even though house construction styles are slightly different in various regions of the country, and they are changing in some areas, the majority of rural people still rely on local forests for their house construction needs. The preferred species tend to vary according to availability and the specific use within the construction scheme. As well, the quantities required and the replacement period varies depending on the style of house and species used now a day is introduced in house construction like concrete roofs, iron doors and windows but plants still play a very important role in the construction of homes. *Croton macrostachyuse* is one of the species used for roof construction. Leaves, branches and poles of these species are used, as most of the local houses have mud roofs.

Croton macrostachyuse used for the preparation of malt (*bikil*) around North Shoa. The grains are first cleaned of in a clean *insira* or broken*insira*, rinsed repeatedly and then soaked in clean water for one day at ambient temperature (20-23^{0}c). After draining excess water, the grains are wrapped in portions of large leaves of *Croton macrostachyuse* and kept moist. Each type of cereal malt is stored separately in a dry place until required. According to Talemos Seta *et al.* (2013) [101], in Wolayta Zone trees like *Olea europea* ssp. *Cuspidata*, *Podocarpus falcatus*, *C. macrostachyus*, *C. africana* and *Ficus vasta* are deliberately left in the open space. The above trees

provide shade as well as suitable places for conducting ceremonies and get-togethers for the villagers during social gatherings and religious holidays where coffee and snacks (of roasted grains) and bread may be served. However, this practice is declining due to the consequent decrease in land holdings.

Fig 3a: Yoke, b. Traditional pestle and mortars c. Small stool

Traditional and modern agroforestry potentials of *Croton macrostachyus*

Shade in Coffee Plantation

Many tree crops such as coffee, cacao, and tea are often grown under shade trees. Shade trees may reduce water stress in hotter areas and provide an additional source of nitrogen for the coffee if they are nitrogen-fixers. Shade trees may also provide habitat for wildlife and play a vital role in traditional medicine to combat various infectious diseases (Giday Yirga *et al.,* 2011) [18].

Cultivation of coffee involves planting of young coffee plant in the understorey of main native tree cover, which principally includes *Croton macrostachyus* (FAO, 1968) [28]. Further, in southwestern Ethiopia, natural forests are also common where *Coffea arabica* grows as understorey plant (Tadesse Woldemariam, 2003) [100]. The favorable considerations for shade trees encompass temperature regulation, suppression of the major weeds of coffee, cheaper production, reduction of hail damage and better growth under high altitude conditions (Beer *et al.,* 1998) [16], as well as maintenance of biodiversity (Perfecto *et al.,* 1996) [86]. The roles of shade trees in contribution of massive organic matter and losing of soil erosion are also well-addressed (Beer *et al.,* 1998) [16]. Furthermore, most common coffee shade trees are also acknowledged for their good capacity in formation of symbiotic associations with certain soil bacteria, rhizobia (Grossman *et al*., 2006) [39] and are vascular mycorrhizal fungi (Tesfaye Wubet *et al.,* 2003) [104] all of which play a pivotal role in improvement of soil fertility and boosting of yields of associated crops. Apart from contribution to understorey, coffee bushes, farmers derive incalculable benefits from shade trees (FAO, 1968; Beer *et al.,* 1998; Tadesse Hailu *et al.,* 2000; Peeters *et al.,* 2003) [28, 16, 99, 85]. Smallholder coffee producers obtain supplementary advantages from diversification/intercropping farming method to promote the household economy (Reddy *et al.,* 2004) [88]. *C. macrostachyus* has been used in traditional agro forestry systems in southwest, west, northwest, and central parts of Ethiopia (Yeshanew Ashagrie *et al.,* 1998) [119]. Dechasa Jiru (1999) [24] reported increased yield of finger millet by 15% under the canopy of the tree than at 15 m away from the tree canopy. Yeshanew Ashagrie *et al.* (1998) [119] also noted the decreased maize yield as distance from the C. *macrostachyus* tree canopy increases compared to the yield obtained under the tree canopy (Fig. 4). Many birds as well as mammals such as monkeys depend on the tree for use as a habitat and sometimes on the fruit and/or seeds during food scarcity.

The main advantages of growing coffee under shade tree are: (a) reduction of light intensity and day time temperature in hot areas: this helps to control the cropping level and reduce overbearing dieback in areas where rapid growth might otherwise lead to these problems (Baggio *et al*., 1997; Beer *et al*., 1998; Muschler, 2001) [13, 16]. (b) Protection from wind and hail; (c) protection of soil from the impact of falling rain and reduction of soil temperature and evaporation (Clarke and Macrae, 1988) [20]. (d) The weeds found in shaded coffee are less harmful and are easier to control; addition of nitrogen to the soil by the root nodules of leguminous shade trees (Roskowski, 1982; Babbar and Zak, 1994; Snoeck *et al*., 2000) [91, 12, 97].

On the other hand growing coffee under shade trees has disadvantages under different conditions: (a) under dry conditions, the shade trees compete with the coffee for soil moisture; (b) shade trees require regular pruning and thinning to prevent the shade becoming excessive; which can cause damage to the coffee; (c) if the shade is dense, the coffee stems become etiolated and weak and are liable to break if the normal (uncapped) multiple stem pruning system is followed.

Fig 4: Croton macrostachyus along maize farm border

Land improvement (mulch, soil and water conservation)

Many indigenous species provide environmental benefits as well as multiple economic uses. It is known that many indigenous trees have positive effects on soil properties, and contribute to the environmental sustainability of traditional agro-forestry systems (Young, 1987) [124]. Indigenous trees play a well-recognized role in maintaining and improving agricultural production by protecting water supplies, stabilizing soil, and by improving soil fertility and water retention. The leaf fall from deciduous trees provides mulch. Mulching is any material used at the surface of a soil to assist in soil productivity may be designated as mulch. Mulches comprise plant material and residues, litter and other products

(Ong, 1996) [84]. *Croton macrostachyus* is native indigenous tree in Ethiopia employed in soil conservation. It is a species commonly planted for the useful shade that provide and its leaf fall provides mulch and green manure. The purpose of mulching is many and varied. The mulch could reduce direct evaporation from the soil surface. It also reduces wind speed and radiation at the soil surface. Thus, mulching is regularly utilized to conserve moisture, improve microclimate and reducing soil erosion. Mulching, through increased activities of soil fauna, improves soil structure and fertility (Khun, 1987; Wallace, 1996) [55, 111]. Mulching influences organic matter content, availability of soil nutrient and soil compaction, which are helpful for better plant growth (Ranganathan and Wit, 1996).

In many Sub-Saharan African countries, mulching is a commonly applied method to reduce soil fertility decline. Crop residues are left on the field. This minimizes the export of nutrients via harvested crops or even imports nutrients when using mulch material produced elsewhere, Mulching increase not only nutrients and organic material content of soils, but also reduces soil erosion, enhances water conservation and increases in filtration. *Croton macrostachyus* is also recommended for planting in soil and water conservation measures (Azene Bekele *et al.*, 1993; Gilbert, 1995) [11, 38].

Improving soil fertility with high nutrient recycling potential

Tree/shrub species with biomass that are characterized by relatively higher nutrient content and faster decomposition rates are regarded as having high litter quality (Myers *et al.*, 1994, Mafongoya *et al.*, 1998) [81, 67] and hence desirable in agro forestry systems. Owing to its high N and P, accumulation and high decomposition rate *C. macrostachyus* could be classed among the species with high nutrient recycling potential that may improve soil's fertility in agroforestry systems (Jiregna Gindaba *et al.*, 2004a) [47]. It is known for its high litter production and rapid decomposition after a period of leaf shedding due to drought (Gilbert, 1995; Jiregna Gindaba, 1997; Yeshanew Ashagrie *et al.*, 1998; Dechasa Jiru, 1999) [38, 44, 119, 24]. *C. macrostachyus* litter underwent more rapid mass loss and nutrient release than the leguminous *Milletia ferruginea* (Hochst.) Baker (Jiregna Gindaba *et al*., 2004a) [47]. This fast litter decomposition rate enriches the soil by releasing nutrients that had been sequestered in the leaves. In line with this, (Yeshanew Ashagrie *et al.*, 1998) [119] had reported that the concentrations of available phosphorus, cation exchange capacity (CEC), exchangeable cations (Mg, Ca, K, Na), soil organic carbon and total nitrogen were higher in the soil samples under the canopy of *C. macrostachyus* than at a distance of 8 m from the tree canopy. Regardless of their extensive surface roots that may pose intense competition with crops, the effect of *C. macrostachyus* and *C. africana* on underneath soil was positive due to the return of high quality litter to the soil (Jiregna Gindaba, 2005b) [49]. Yeshanew Ashagrie *et al.* (1999) [120] observed similar higher positive mean values of soil fertility parameters, under canopies of *Croton macrostachyus* trees as compared to adjacent open land in traditional agroforestry system in northwestern Ethiopia.

According to Jiregna Gindaba *et al.* (2004b) [46], *Croton macrostachyus*, increases soil nitrogen, which was attributed to tree leaf and root litter. Since *Croton macrostachyus* is not nitrogen-fixing plant the only way it could have improved soil nitrogen is by absorbing N from the subsoil and depositing through litter fall. In many parts of Ethiopia, farmers collect leaf litter and pollarded branches from *Croton macrostachyus*, and incorporated into crop fields to enrich soil fertility on selected sites (Eyasu Elias, 2002) [27]. Thus, the use of this species in association with crops should be accompanied by the amputation of surface roots that may compete with crops. Because *C macrostachyus* and *C. africana* produce extensive lateral roots to hold the soil, they may be good candidates for planting on hillsides where erosion is a problem.

Coping with nutrient stress

Soil nutrients, especially N and P are the major components of cell structure and the ultimate effect of nutrient deprivation in plants is stunted growth, which may result in death of the plant depending on the degree of the deficiency. Trees undergo both physiological and anatomical adjustments to survive in nutrient stressed environments (Kozlowski *et al.*, 1991) [57]. Reduction of leaf area and allocation of more biomass to roots (increased root weight ratio) were observed both in the deciduous trees under soil N and/or P stress (Jiregna Gindaba, 2003) [45]. Roots of deep rooting trees are capable of pumping nutrients that are otherwise unavailable to shallow rooted plants (Van Noordwijk *et al.*, 1996; Young, 1997) [110, 123]. This pumping of nutrients is crucial in tropical environments because many tropical soils are highly leached and depleted of weather able minerals to great depth (Young, 1997) [123]. Nutrient resorption from senescing leaves and storage in perennial tissues increases intersystem nutrient cycling (Aerts, 1996) [6]. It enables plants to reuse these nutrients and as such, it is a major nutrient conservation mechanism (Wendler *et al.*, 1995, Aerts, 1996) [113, 6]. *C. macrostachyus* in parkland, Wondo Genet area, had high N and P resorption (Jiregna Gindaba *et al.*, 2004a) [47]. Allocation of more nutrients to mycorrhizal associates also increases nutrient uptake, especially P. *C. macrostachyus* forms high degree of mycorrhizal association (Tesfaye Wubet *et al.*, 2003) [104], which might also contribute to the high level of P in tissues of this plant (Lüttge *et al.*, 2002, Jiregna Gindaba, 2003; and Jiregna Gindaba *et al.*, 2004a) [65, 45, 47].

Source of fuel used for fire wood and charcoal

Firewood is the main source of energy for rural households, and is an important source of cooking fuel in towns. In rural areas, many people rely solely on firewood for cooking and other household tasks. It is generally the preferred fuel for cooking and heating water. In urban areas, people rely less on firewood and tend to use more charcoal. Wood is the oldest fuel known to man. Since time immemorial, it has been meeting energy needs for domestic activities such as cooking and heating. Until the middle of the nineteenth century, wood was the sole or principal source of domestic and industrial energy worldwide. In developing countries, the process of replacing fuel wood is still in its initial stages, and wood continues to be the dominant fuel for domestic cooking and heating. *Croton macrostachyus* is used as fuel that burns even

when green, but with a rather unpleasant spicy odor and much smoke; it is also used to make charcoal. The demand for fuel wood is increasing, which has intensified the extraction of mature trees leading to increased tree deaths of this species especially in west and east Shoa and Wollega zones.

Adaptation to arid environment

Stomatal closure and reduction of leaf area

Plants develop adaptive resistance to moisture stress to maintain vital physiological processes under water stress conditions (Kramer and Boyer, 1995; Nilsen and Orcutt, 1996) [58, 83]. Deciduous species are more sensitive to moisture stress (Kozlowski *et al.*, 1991) [57] they employ various mechanisms to maintain their water balance. Physiological and morphological changes occur in plants in response to severe water stress or drought (McKersie and Leshem, 1994; Nilsen and Orcutt, 1996) [71, 83]. As a result, field planting followed by absence of rain for several days would diminish the success of seedlings. But the degree and mechanism of tolerance to severe water stress varies from species to species and this variation could be picked for recruiting species for planting in areas prone to water stress. Mechanisms employed to avoid or tolerate water stress include stomatal closure, leaf re-orientation, leaf shedding, allocation of more biomass to roots and deep rooting. (Less transpiration rate can considered as change in physiology)

Stomata play key role in controlling the balance between water loss and carbon gain, i.e. biomass production (Kramer and Boyer 1995; Lambers *et al.*, 1998) [58]. Stomatal closure is regarded as the initial impact of water limitation on photosynthesis (Nilsen and Orcutt, 1996) [83]. According to Jiregna Gindaba *et al.* (2004b) and (2005a) [46, 48], stomatal control was the main line of water stress management in the short term of deciduous species. *C. macrostachyus* showed a more rapid stomatal response to severe water stress than the eucalypts. This rapidly reduced stomatal conductance closely followed reduction in leaf water content with increasing water stress. *C. macrostachyus* seedlings a characteristic of drought tolerant plants (Nilsen and Orcutt, 1996) [83] maintained less open stomata compared to eucalypts in water stressed conditions.

C. macrostachyus showed strong stomatal control of gas exchange by the reduction of leaf area and shift of the stomatal control to further reduction of leaf area was observed in all the deciduous species when water stress persisted (Jiregna Gindaba *et al.*, 2004b and 2005a) [46, 48]. Leaf area adjustment has been an efficient strategy at least to keep the plant longer in water stressed environments (Kozlowski *et al.*, 1991) [57]. After shedding their leaves, deciduous trees can survive long periods of water stress by remaining dormant. However, reduction of leaf area diminishes total photosynthetic output that in turn results in decreased growth rate (Kozlowski *et al.*, 1991, Jiregna Gindaba, 2005a 48) [57, 48]. In a study on stomatal responses of indigenous tree species of Ethiopia to increasing water stress, Legesse Negash (1992) [61] also detected the presence of pronounced midday stomatal closure, leaf re-orientation showed an advanced mechanism of minimizing water loss, which enabled it to utilize water in a very conservative manner (Jiregna Gindaba *et al.*, 2004b) [46]. *C. macrostachyus* had significantly higher transpiration rates per leaf area compared to the eucalypts. Following its high water loss rates from its leaves, *C. macrostachyus* is dehydrated earlier than the eucalypts However, this species persisted drought condition much longer than the eucalypts mainly because of its rapid leaf area reduction.

Production of extensive lateral root

Investment in more root biomass for absorption was another important mechanism by which deciduous species such as *C. macrostachyus* to maintain its water balance (Jiregna Gindaba *et al.*, 2005a) [48]. Plants with extensive root systems are favored to survive in resource poor environments, because they are more likely to tolerate occasional severe droughts and encounter the nutrients that are distributed irregularly in many soils. Similar to the seedlings, mature *C macrostachyus* plants also produce extensive lateral roots under natural conditions (Jiregna Gindaba, 2005b) [49]. The wide distribution of *C. macrostachyus* in all kinds of habitats in Ethiopia (Gilbert, 1995) [38] could be due to its extensive lateral roots (Jiregna Gindaba, 2005b) [49]. *Croton macrostachyus* has a long taproot and numerous side-roots, which makes it adapted to dry climates.

Propagation, tree management and plantation of *Croton macrostachyus*

Plant propagation is the duplication of a plant from a source (mother plant). The ultimate objective of propagation is to produce more plants like the parent. *C. macrostachyus* is naturally regenerated mostly from seeds (Gilbert, 1995; Azene Bekele *et al*., 1993) [38, 11]. Direct seeding is preferred and Pre sowing treatment is not necessary. Under ideal conditions, seeds germinate within 30-60 days, with an expected germination rate of healthy, mature seed lots being about 40-70%. The seeds are sown in a mixture of sand and compost and kept moist. If planted in a nursery transplanting should be done at the 2-leaf stage. However, due to widespread human interference, natural regeneration of the species has been very difficult except by coppicing from existing stump sprouts. Many species of trees and shrubs can resprout after the whole tree has been cut. When this ability is used to regenerate the tree, the practice is known as coppicing. Coppicing can almost be regarded as a method of tree propagation since it can substitute for the task of planting a new tree after a mature one is felled. The height at which trees are cut for coppicing can vary from near the ground to about knee height. Coppicing should be done towards the end of a dry season or just at the beginning of a rainy season to allow the coppiced plants to regrow.

Lopping, pollarding and coppicing are suitable practices of tree management. *Croton macrostachyus* can be lopped, pollarded or coppiced (Fig.5). It grows well both in shade and bright sunlight; it is vulnerable though to cold wind and frost, especially young plants which should be protected during the first two years. *Croton macrostachyus is* fast growing on good sites but grow slowly on drier sites.

In a study of the regeneration of woody species under plantations of exotic species including *Eucalyptus globulus* and a natural forest in southeastern Ethiopia (Feyera Senbeta *et al.*, 2002) [30], *C. macrostachyus* ranked among the top five tree species to regenerate in both the plantations and the

natural forest. Mulugeta Lemenih *et al.* (2004) [80] in plantations of other exotic and indigenous species as well as in natural forests reported a similar result. The high density of *C. macrostachyus* seedlings in *E. globulus* plantations. Feyera Senbeta *et al.* (2002) [30] indicates the capacity of the species to regenerate under intense competition and poor nutrient conditions because soils under plantations of eucalypts are usually poor in nutrient reserves compared to nearby open areas or natural forests.

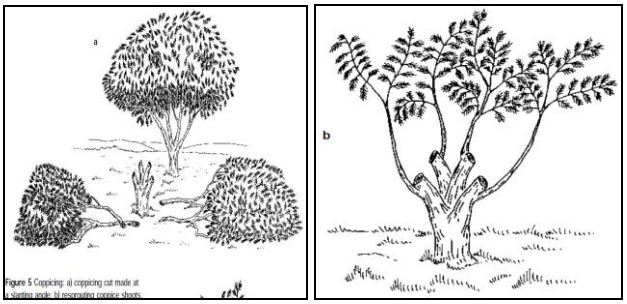

Fig 5.A): Coppicing cut made at a slanting angel, B) Resprouting coppice shoots

Conservation status of *Croton macrostachyus*

Individual trees of the species are found scattered in farmlands, along roads, in graveyards, as well as in forest areas. In most places, trees are highly degraded through pollarding and lopping (Kebebew Wakjira, 2007) [54]. On top of this, the scarcity of other forest trees due to forest destruction has led to the increased cuttings of *C. macrostachyus* for construction, use as farm implements such as *KEMBER*, and traditional pestle and mortars (Kebebew Wakjira, 2007) [54]. In addition to these, demand for fuel wood is increasing, which is intensified the extraction of mature trees leading to increased tree deaths of this species especially in west and east Shoa and Wollega zones. In contrast, intentional cultivation of the species has never been undertaken, thus further jeopardizing the very survival of the species. For example, nursery technicians at Gedo, west Shoa, reported that they do not carry out *C. macrostachyus* seedlings propagation, as it is difficult to initiate germination of the seeds (Kebebew Wakjira, 2007) [54]. Conservation of the species is to be seen in the context of efforts directed to the *in situ* conservation of natural ecosystems, habitats and vegetation types. Due to widespread human interference, natural regeneration of the species has been very difficult except by coppicing from existing stump sprouts. Conservation of the species is to be seen in the context of efforts directed to the *in situ* conservation of natural ecosystems, habitats and vegetation types.

Conclusion

One of the plant species that is known for its medicinal use is *Croton macrostachyus* (*Euphorbiaceae*). In areas where it is native, the plant (or its parts) is used for treatment of several human health problems. Despite the many medicinal uses, not much research has been done concerning the chemical composition and pharmacology of the different plant parts and more research is warranted. *Croton macrostachyus* has several other important uses, e.g. to control soil erosion, as a shade tree, as green manure and bee forage. The farmers especially in Hararghe and shoa use it to protect stored grain from pests. *Croton macrostachyus is* suitable for indoor carpentry, ordinary furniture, veneers, boxes, tool handles, and inner layer of play wood. In most rural areas of Ethiopia, the scarcity of other forest trees due to forest destruction has led to the increased cuttings of *C macrostachyus* for construction, use as farm implements and traditional pestle and mortars. In addition to these, demand for fuel wood is increasing, which is intensified the extraction of mature trees leading to increased tree deaths of this species. In contrast, intentional cultivation of the species has never been undertaken, thus further jeopardizing the very survival of the species. Propagation of *Croton macrostachyus* could therefore be achieved by means of seeds, which is practically, and Economically Advantageous. The establishment of trees that provide biomass for fuel, soil nutrient recycling, water retention, construction material, shade, other environmental services, and traditional medicine is a basic requirement for sustained livelihood of farmers. In order to ensure the management and conservation of useful plants, documenting of indigenous knowledge system is essential. Documenting the uses of *Croton macrostachyus* in the areas of Ethiopia where it grows is essential. For this reason, this review is initiated to gather record and document indigenous knowledge of the species. The review may help in better understanding of the occurrence, distribution, local uses, and propagation and conservation status of this plant for its proper utilization.

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