Genetic Resources Transfer and Regulation Directorate, IBC

The prospectus of *Phytolacca dodecandra* (Endod)

for commercialization and industrial utilization

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Contents

1. Introduction

There is enormous potential in Ethiopia to develop a profitable industry based on plant genetic resources. The development and commercialization of plant based bio-industries is dependent upon the availability of information concerning bio-active agents, bio-processing, extraction, purification, and marketing of the industrial potential plants and abundance of the resource. Based on these criteria, endod is the most promising and extensively studied plant genetic resource for commercialization and industrial utilization.

Researches on the toxicity, chemistry, extraction and application, agronomic aspects, molluscicidal and other properties of endod were intensively studied. Research results confirmed that endod have molluscicidal properties (useful for schistosomiasis and zebra mussels control programmes) and detergent properties (useful raw material for soap factory). Endod berries also have been discovered to possess potent spermicidal properties useful forbirth control; aquatic insect larvicidal properties potentially useful in the control of mosquitoes andother water-breeding insects; trematodicidal propertiesfor control of the larval stages of *Schistosoma* and *Fasciola* parasites; hirudinicidal properties for control of aquatic leeches; and fungicidal propertiesfor the potential topical treatment of dermatophytes. Endod's potential to control Zebra mussels provides additional economic incentives to develop it (Aklilu Lemma *et al.*, 1984; Legesse Wolde-Yohannes *et al.*, 1999).

Since the discovery of the molluscicidal properties of endod in 1964, more than 40 scientific articles have been published on different aspects of the plant (Aklilu Lemma *et al.*, 1991). Despite of all these industrial applications, endod has not been put to use in large-scales to realize its full potential. Recently EthioAgri-CEFT PLC, one of the members of the MIDROC Ethiopia Investment Group is running large-scale commercial farms for the cultivation of endod. It is also planned to export the product to markets in Europe and America. Generally, endod's industrial potential is under-utilized and therefore there is a need to promote endod towards large-scale production and processing for local and international marketing.

2. General description of endod

Endod is the Ethiopian vernacular name for the soap berry plant *Phytolacca dodecandra*. It is a member of the phytolaccaceae family and it is widely distributed in Africa, South America and Asia. It is an indigenous plant to Ethiopia (Azene Bekele, 2007).

The plant is a climber with hanging branches. It may grow to a height of 10m though the average height is 2-3m. Under favorable conditions it fruits twice a year (Ethiopia). It is a common wild plant in the highlands of Ethiopia, particularly in undisturbed areas around churchyards and close to fences. The ecological distribution and habitat of endod in Ethiopia is limited to highland regions (Legesse Wolde-Yohannes, 1987).In Ethiopia *Phytolacca dodecandra* flowers and fruits throughout the year, but with a peak during the dry season, from October to April. However, in some parts of Ethiopia it fruits twice a year, in December–February and in June–July (Lugt, 1981; Legesse Wolde-Yohannes, 1992).

3. Agronomic aspects of endod

A major goal of these studies is to select and breed plants for favorable growing characteristics, productivity and high potency of berries.

Breeding

65 different strains and varieties of the endod plants were collected from different parts of Ethiopia and studied under comparable conditions. Three strains- E3, E17 and E44 have been selected for exceptional growth, molluscicidal potency, yield and resistance to insect pests and drought. Based on the color of the fruits, two types of plants can be distinguished in Ethiopia: ‘Arabe’ with pinkish to red fruits and ‘Ahiyo’ with yellowish green fruits. The first type has higher saponin content than the latter one (Legesse Wolde-Yohannes, 1983; Legesse Wolde-Yohannes *et al.*, 1987; Kassa Semagn *et al.*, 2004).

Yield

In Ethiopia, the best strain (E44) has produced 3000 kg of dried berries per hectare annually. Annual fruit yield increases with the age of the plant up to about 15 years, with the greatest increase occurring between the first and third year (Legesse Wolde-Yohannes, 1992).

Harvesting

The fruits of *Phytolacca dodecandra* are harvested when full-grown but still green as the saponin content is then highest. Ripe fruits are hard to harvest as they fall from the plant and are eaten by birds. Complete fruit bunches are collected manually (Legesse Wolde-Yohannes, 1992; Zimudzi, 2007).

Propagation and planting

Propagation of *Phytolacca dodecandra* is by seed or by cuttings. Seed propagation results in equal chances of producing male and female plants, and the plants start flowering 2 years after sowing. Germination can be improved by scarification with sand. Fruits can be stored for up to one year without loss of viability, but after 4 years of storage, germination declines by 14%. Propagation by seed is only appropriate for selection purposes. Seed of *Phytolacca dodecandra* takes about 14 days to germinate. Clonal propagation is possible through non-woody cuttings with 2–3 nodes taken from the top or middle part of the plant. Rooting occurs with or without application of plant growth regulators. Rooted cuttings flower after about 6 months. Tissue culture has been successful for propagation, but the plants take about 18 months to flower. Procedures for routine micro propagation by shoot tip and nodal culture have been developed. In Ethiopia, six-week-old cuttings are transplanted in the field in holes of 60 cm × 60 cm, in a mixture of soil and manure or peat, at the beginning of the rainy season. Survival of transplants depends on availability of water for irrigation (during the first and possibly during the second dry season), control of pests, evapotranspiration and soil salinity (Makhubu *et al.*, 1987; Zimudzi, 2007).

Management

Plantations of *Phytolacca dodecandra* must be shaded in the first weeks after planting. Occasional watering and weeding are important until the crop has become established. For large-scale cultivation, plants should be spaced 2 m between rows and 1–2 m between plants. For each 10 female plants, 1 male plant must be planted to ensure pollination. Annual pruning is necessary to maintain size and shape and to obtain maximum yield. Without pruning the plants become a tangled mass and the fruits are difficult to harvest. Pruning is done by removing the long horizontal branches and shortening erect branches. Intercropping with annual crops is possible

because the plant develops few and deep taproots and does not compete much with annual crops for moisture and plant nutrients (Legesse Wolde-Yohannes, 1983; Legesse Wolde-Yohannes *et al.*, 1987).

In a field test, the best growth and the highest fruit yield were obtained with plants grown in full sunlight, under irrigation and with application of cattle manure. Irrigation was beneficial to fruit yield but reduced the saponin concentration; however, irrigation is beneficial for the total saponin yield. Addition of manure significantly increased growth and fruit yield, but the saponin concentration was lower. The combination of cattle manure and irrigation resulted in the highest total saponin yield (Legesse Wolde-Yohannes, 1983; Legesse Wolde-Yohannes *et al.*, 1987).

4. Ethnobotany of endod

Parts of the endod plant have been used as a detergent and traditional medicine for centuries in Ethiopia (Aklilu Lemma, 1970; Esser *et al.*, 2003; Azene Bekele, 2007). Common medicinal uses include treatment of skin itching (ringworm), abortion, gonorrhea, leeches, intestinal worms, anthrax and rabies (Essera *et al.*, 2003).

5. Industrial potential of endod

5.1. Molluscicidal property

Endod is one of the most promising plant molluscicides due to its high toxicity to the snails, low toxicity to mammals, stability under various environmental conditions, biodegradability, widespread distribution in tropical Africa and potential for large-scale cultivation (Legesse Wolde-Yohannes, 1992; Molgaard *et al.*, 2000). One of the most important criterion for widespread use of any molluscicide is its safety to humans, animals using the treated bodies of water and local flora and fauna. Toxicological studies also showed that the fruit extracts do not have mutagenic or carcinogenic properties (Aklilu Lemma and Yau, 1974; Lambert *et al.*, 1991).

Endod berries have been used for washing clothes in streams and lakeshores in Ethiopia and other parts of Africa for centuries, with no apparent toxic effect. Also, in Ethiopia and elsewhere in Africa, high concentrations of the endod leaves, roots, or berries are taken orally for various medicinal purposes, such as for purging intestinal parasites and for abortion (Stolzenberg

andParkhurst,1976). If endod had any harmful effects, surely it would not have survived centuries of human use. As with all natural products used by local people, its dangers would have been recognized and the substance discarded.

The scientific working group of schistosomiasis of the UNDP/World Bank/WHO special program of research and training on tropical diseases recognized *Phytolacca dodecandra* (endod) as the most promising plant molluscicide studied to date (Aklilu Lemma *et al.*, 1991).

Many well-intentioned water resource development (hydroelectric dams and irrigation) schemes provide more sites for snails to breed and thus for the rapid spread of schistosomiasis. In Ethiopia, it is expected for schistosomiasis to spread rapidly due to many irrigation and dam projects undergoing recently. This will result in increased demand for most accessible and cost effective molluscicide. Hence, there will be a potential market for endod products.

An endod-based molluscicide intended to control the zebra mussels has opened a major new hope for marketing and exporting endod as a cash crop. The zebra mussels are disrupting municipal water facilities because they restrict water flow by attaching themselves to pipes and other hard surfaces. In addition, they are a serious threat to fisheries because the mussels cover rocks in spawning areas, and remove algae (a source of nutrients) from the water. Municipal water plants and ship owners had already spent millions to rid their pipes of zebra mussels. The U.S. Fish and Wildlife Service estimated in 1990 that the zebra mussel would create a $2 billion loss to fisheries by the end of the decade. If endod is commercially developed as a molluscicide to control zebra mussels, there would be immediate demand for large quantities of endod berries. So, a new and substantial export market could be created in Ethiopia for endod as a raw material or processed product (Rafi, 1993).

5.2. Detergent and foaming properties

The detergent properties of endod are also promising. Its foaming, thermal stability and cleaning properties equals or exceeds most imported or locally-made detergents in developing countries. The water extract of endod can be used as an effective substitute for dodecyl benzene sulfonic acid (DOBSA), a petrochemical by-product used as a surfactant in commercial detergent formulations for washing fine grades of cotton, linen and wool. From acceptability viewpoint, endod has been used locally for centuries. People in the Ethiopian highlands have used endod

berries as laundering agents for the white cotton shawls (shama) that are a part of the Ethiopia culture (Aklilu Lemma, 1965; Adams *et al.*, 1989).

Endod is more advantageous over some chemical detergents as it is harmless to delicate fabrics (such as fine cotton, linen and wool) and leaving the clothes non-compressed. Further, it is biodegradable and its use has no apparent deleterious environmental effects (Aklilu Lemma, 1984).

The high foaming property of endod could be modified for use in lightweight concrete and foam rubber. It may also be possible to use it as a dispersant in perfume manufacture (Aklilu Lemma *et al*., 1979; Aklilu Lemma, 1984).

5.3. Larvicidal properties

Studies at Harvard University on the comparative toxicity of endod and other compounds on stream flora and fauna showed that mosquito larvae are particularly susceptible to the lethal effect of endod (Karunamoorthi *et al.*, 2008). This led to other investigations which demonstrated the susceptibility of larvae of the notorious black fly (*Simulium* spp.) and larvae of the domestic house fly, *Musca domestica*. Further development of endod as an insecticide for village use could have public health significance. Since snail and malaria-transmitting mosquitoes may breed in the same type of environment, control of snails with endod may have the added benefit of reducing mosquito populations

5.4. Hirudinicidal property

The aquatic leech, *Lymnatis nilotica*, a major animal pest of livestock in many tropical countries, is susceptible to endod (Aklilu Lemma *et al.*, 1984). Endod has been used for centuries in Ethiopia to control this pest. This use should be improved for more effective protection of domestic animals against this debilitating ectoparasite.

5.5. Trematodicidal property

Schistosome cercariae and other trematode larvae are highly susceptible to endod. Infected waters can be rendered safe for several days by application of small quantities of endod. The active ingredient can also be prepared in ointment form for application on exposed skin of

workers in irrigation canals as a prophylaxis against cercarial penetration (Aklilu Lemma and Yau, 1974).

5.6. Spermicidal properties

Endod-derived saponins were found to have potent spermicidal activity, thus suggesting its possible use as birth control agent (Stolzenberg and Parkhurst, 1974). Endod has long been known and is widely used as abortifacient in traditional societies in Ethiopia. Laboratory studies have shown it to cause strong uterine contractions (Stolzenberg and Parkhurst, 1976). Intrauterine injection of small quantities of endod extract in pregnant mice causes sterile and apparently harmless abortion. In addition to preventing pregnancy, it may be used as a "day after" pill (Stolzenberg and Parkhurst, 1974).

5.7. Other snail-killing properties

Endod is also effective against snails that transmit other important human and animal diseases besides schistosomiasis. Laboratory and field studies have indicated that *Lymnaea* spp are extremely susceptible to endod. These are the snail hosts of important cattle and sheep liver fluke that cause fascioliasis. Spraying pastures with relatively low concentrations of ended will kill snails, eggs, and infective larvae of the parasites without affecting the animals or vegetation on which it is sprayed (Zimudzi, 2007).

5.8. Fungicidal properties

Biological screening tests have revealed that endod has a selective toxicity to dermatophytes, the fungi that cause a variety of skin conditions such as athlete's foot and ringworm (Wossen and Aklilu Lemma, 1977).

6. Conclusion and Recommendation

Genetic resources that have pharmaceutical or other industrial potential should be promoted for access and benefit sharing. Endod is the best known plant genetic resource for its enormous potential for commercialization and industrial utilization.

Its industrial value and its potential to become an investment project in which farmers can be involved as out-growers make endod an economically significant plant. Promoting endod will

thus contribute to the sustainable livelihoods and community development by optimizing its use and generating income.

The benefits of endod go well beyond the potential applications of its many different properties. To realize its full potential, there is a need to promote endod towards large-scale production and processing for local and international marketing

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