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Review Article

Moringa: A Miracle Plant for Agro-forestry

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ABSTRACT

Moringa (*Moringa oleifera* Lam.) has gained much importance in the recent days due to its multiple used and benefits to agriculture and industry. Regarded as a miracle plant, all the parts of moringa plant are used for medicinal and other purposes. Recently, the roles of aqueous extracts of various parts in enhancing plant growth and productivity have been explored, making it even more valuable plant species. The focus of this review is to encompass the research so far conducted in exploring the potential of moringa for medicinal uses, moringa oil as lubricant in industry as well as biodiesel, as biopesticide, as nutritional source, in enhancing plant growth and productivity both of the normally growing and stressed plants. Special focus has also been places on the recent research efforts carried out at University of Agriculture, Faisalabad, Pakistan. We believe that this review will help further exploring the novel avenues of research using Morigna as a valuable plant for benefits of mankind. © 2012 Friends Science Publishers

Key Words: Moringa; Agro Forestry; Nutrition

INTRODUCTION

Forests have a significant role not only in ensuring the environmental stability but also achieving economic benefits. Forest is not just a group of trees, but is an ecosystem in itself, comprising all the living and non-living components. The main living components of a terrestrial ecosystem are plants dominated by trees. The importance of forests in the ecosystem can never be underemphasized (Barančeková *et al.,* 2007). Forests have numerous roles to play both natural and manmade. Natural functions involve protective and regulative services, while man imposed functions relate to production and socio-ecological services. Plants are valuable for us in many ways, besides protecting and improving the environment in which we live, they control run off, check floods and soil erosion, improve soil fertility and help in reducing temperature and pollution. Thus they work as environmental conditioners.

Pakistan is among the ten most populated countries in the world, with a geographic area of 493,963 km^2 and a population of over 135 million, with a population density of 389 persons per square mile (World Almanac, 1998). Forest products and services once thought to be abundant are now known to be scarce in the country; Pakistan suffers far more severe forest scarcities than most countries in South Asia. Its natural forest assets are small, with forest area and national land utilization figures ranging from 3.1% to 3.6% of total land area (Khan, 2002). Forest or woodland area per person is one of the world's lowest (1/13th a hectare) and most forests are slow-growing. The population is growing at 2.3% annually (Human Development in South Asia, 2002). About 4.2 million ha of Pakistan is under forests.

Importance of Forests can be seen in five ways; (a) regulate climate and water resources, (b) serve as habitat for plants and animals, (c) furnish a wide range of essential goods such as wood, food, fodder, medicines and other necessities of life, (d) add in soil fertility, cut down erosion and mitigate desertification, decrease floods, protect wild life and (e) provide opportunities for recreation, and other services (Anwar, 2007; Price, 2007).

Agro-forestry provides 60% Timber and 90% fire woods. The most important plants recommended for Agro-forestry includes: Moringa, Acacia, Neem, Ber, Mulberry, Dalbergia, Poplar, Simbal, Olive etc. "Moringa" is the most potential tree for arid and semi arid climatic zones with multiple benefits.

Moringa: Moringa belongs to the Moringaceae a single-genus family with 13 known species. *Moringa oleifera* Lam. is the most common known and utilized species. *M. oleifera* is native to the sub-Himalayan regions of northwest India and Pakistan. It is also indigenous to many other countries in Southeast Asia, Africa, Arabia, Caribbean islands, and South America (Fahey, 2005). It grows best in dry sandy soil, it tolerates poor soil,

including coastal areas. It is a fast-growing, drought-resistant tree. Today it is widely cultivated in Africa, Central and South America, Sri Lanka, India, Mexico, Malaysia, Indonesia and the Philippines. Moringa is a short, slender, deciduous, perennial tree, to about 10 m tall; rather slender with drooping branches; branches and stems brittle, with corky bark; leaves feathery, pale green, compound, tripinnate, 30–60 cm long, with many small leaflets, 1.3–2 cm long, 0.6–0.3 cm wide, lateral ones somewhat elliptic, terminal one slightly larger than the lateral ones; flowers fragrant, white or creamy-white, 2.5 cm in diameter, borne in sprays, with 5 at the top of the flower; stamens yellow; pods pendulous, brown, triangular, splitting lengthwise into 3 parts when dry, 30–120 cm long, 1.8 cm wide, containing about 20 seeds embedded in the pith, pod tapering at both ends, 9-ribbed; seeds dark brown, with 3 papery wings. Main root is thick (Foidle *et al.,* 2001). It flowers during early spring and produces fruit between April to June in Pakistan.

It is considered one of the world's most useful trees, as almost every part of the moringa tree can be used for food or has some other beneficial property. In the tropics, it is used as forage for livestock and in many countries, moringa micronutrient liquid, a natural anthelmintic (kills parasites) and adjuvant (to aid or enhance another drug) is used as a metabolic conditioner to aid against endemic diseases in developing countries (Foidle *et al.,* 2001).

Nutritional value: *M. oleifera* is the most nutrient-rich plant yet discovered. Moringa provides a rich and rare combination of nutrients, amino acids, antioxidants, antiaging and anti-inflammatory properties used for nutrition and healing. Moringa is sometimes called "Mother's Best Friend" and Miracle Tree." Since 1998, the World Health Organization has promoted moringa as an alternative to imported food supplies to treat malnutrition (Johnson, 2005; Manzoor *et al*., 2007; Sreelatha & Padma, 2009; http://www.treesforlife, 2005).

M. oleifera is a miracle tree with a great indigenous source of highly digestible proteins, Ca, Fe and Vitamin C. It contains all the essential nutritional elements that are essential for livestock and human beings as well (Fahey, 2005). Some articles and research studies have reported that the dry leaves of *M. oleifera* contain 7 times more vitamin C than orange, 10 times vitamin A than carrot, 17 times calcium than milk, 15 times potassium than bananas, 25 times iron than spinach and 9 times proteins than yogurt (Fuglie, 1999). In addition, it contains vitamin B-Complex, chromium, copper, magnesium, manganese, phosphorus and zinc (Fuglie, 2000, 2001). Thurber and Fahey (2009) statted *M. oleifera* leaves as rich protein source, which can be used by doctors, nutritionists and community health cautious persons to solve worldwide malnutrition or under nutrition problems. According to researchers moringa has the potential to combat vitamin A and other micronutrient deficiencies (Nambiar, 2006). 40139 µg/100 g total carotenoides on fresh weight basis in moringa leaves of which 47.8% or 19210 µg/100 g was β-carotene. Ascorbic acid at 6.6 mg/g on dry weight basis, 0.26 mg/g Fe, 22.4 mg/g calcium, 6.3 mg/g P, 11.2 mg/g oxallic acid and 0.9 g/100 g fiber.

Moringa has been in use since centuries for nutritional as well medicinal purposes. These include vitamin C, which fights a host of illnesses including colds and flu; vitamin A, which acts as a shield against eye disease, skin disease, heart ailments, diarrhea, and many other diseases; calcium, which builds strong bones and teeth and helps prevent osteoporosis; potassium, which is essential for the functioning of the brain and nerves and Proteins, the basic building blocks of all our body cells. Another important point is that moringa leaves contains all of the essential amino acids, which are the building blocks of proteins. It is very rare for a vegetable to contain all of these amino acids. Moringa contains these amino acids in a good proportion, so that they are very useful to our bodies. These leaves could be a great boon to people who do not get protein from meat. Moringa even contains argenine and histidine two amino acids especially important for infants. Argenine and histidine are especially important for infants who are unable to make enough protein for their growth requirements. Experts tell us that 30% of children in Sub Saharan Africa are protein deficient. Moringa could be an extremely valuable food source (Duke, 1987; Babu, 2000; Fugile, 1999, 2000, 2001; Manzoor *et al*., 2007). Given its nutritional value, it can be utilized in fortifying sauces, juices, spices, milk, bread, and most importantly, instant noodles. Many commercial products like Zija soft drink, tea, and neutroceuticals are available all over the globe.

Moringa is an alternative to imported food supplies to treat malnutrition in poor countries. Moringa trees have been used to combat malnutrition, especially among infants and nursing mothers. Three non-governmental organizations in particular "Trees for Life, 2005)", "Church World Service" and "Educational Concerns for Hunger Organization" have advocated moringa as "natural nutrition for the tropics." Leaves were also used for food fortification (Mahatab *et al*., 1987; Fugile, 1999, 2000, 2001; Lockett & Calvert, 2000). In 1997-1998, Alternative Action for African Development (AGADA) and Church World Service tested the ability of moringa leaf powder to prevent or cure malnutrition in pregnant or breast-feeding women and their children in south western Senegal. Malnutrition was a major problem in this area, with more than 600 malnourished infants treated every year. During the test, doctors, nurses, and midwives were trained in preparing and using moringa leaf powder for treating malnutrition (Johnson, 2005; Manzoor *et al*., 2007; Sreelatha & Padma, 2009; UNWFP, 2004).

Possible Uses of Moringa

Moringa in human health: Phytochemicals refers to only those chemicals, which may have an impact on health, or on flavor, texture, smell, or color of the plants,

but are not required by humans as essential nutrients. Moringa contains a range of fairly unique phytochemicals containing the simple sugar, hamnose and it is rich in a fairly unique group of compounds called glucosinolates and isothiocyanates. Six such phytochemicals have been reported to have hypotensive, anticancer and antibacterial activity includes benzyl isothiocyanate, niazimicin, pterygospermin, benzyl isothiocyanate and 4-(a-Lrhamnopyranosyloxy) benzyl glucosinolate (Faizi *et al*., 1998; Fugile, 1999, 2000, 2001; Fahey *et al.,* 2004; Costa-Lotufo *et al*., 2005). Numerous studies now point to the elevation of a variety of detoxication and antioxidant enzymes and biomarkers as a result of treatment with moringa or with phytochemicals isolated from moringa have shown, antiulcer, effect on immune response, spasmolytic activities, hypercholesterolemia effects, antibacterial activity (Talreja, 2010). Sympatholytic activity and antiviral activity against herpes simplex virus type-1 (Gilani *et al*., 1994; Hameed-un-Nisa *et al*., 1998; Ghasi *et al*., 2000; Galan *et al*., 2004; Haristoy *et al*., 2005).

Antioxidants play an important role in inhibiting and scavenging free radicals, thus providing protection to human against infections and degenerative diseases. The extracts of *M. oleifera* both mature and tender leaves have potent antioxidant activity against free radicals, prevent oxidative damage to major biomolecules and afford significant protection against oxidative damage (Yongbai, 2005; Sreelatha & Padma, 2009).

Traditional medicine: Moringa has been used in the traditional medicine for centuries in many cultures around the word, for skin infections, anemia, anxiety, asthma, blackheads, blood impurities, bronchitis, catarrh, chest congestion, cholera, conjunctivitis, cough, diarrhea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation ,diabetes and pregnancy. The healing properties of moringa oil have been documented by ancient cultures. moringa oil has tremendous cosmetic value and is used in body and hair care as a moisturizer and skin conditioner. moringa oil has been used in skin preparations and ointments since Egyptian times (Ramachandran, 1980; Sairam, 1999; Fugile, 2000; Monica, 2005).

Moringa as: livestock feed and fodder: *M. oleifera* is rich in nutrients, which are essential for livestock for weight gain (up to 32%) and increase in milk production (up to 43-65%) (Mathur, 2006). It is also rich in iron, potassium, calcium and multivitamins . Reyes- Sánchez *et al.* (2006) carried out an experiment to see the effect of *M. oleifera* foliage fed at different levels to dairy cows for its intake, digestibility, milk production and milk composition. Imagine what would be possible if milk production in developing countries could be increased in this way. It could prevent untold suffering of people with protein deficiency (Francis *et al*., 1991; Foidle *et al*., 2001).

Moringa leaf extract (MLE): a natural plant growth enhancer: Leaves of *M. oleifera* are rich in zeatin, a cytokinin in addition to other growth enhancing compounds like ascorbates, phenolic and minerals like Ca, K, and Fe that makes it an excellent crop growth enhancer (Anjorin *et al.,* 2010).

Moringa leaf extract is best used as plant growth enhancer (Phiri & Mbewe, 2010). Foidle (1999) carried out a project named "Biomasa" to grow moringa and explored the foliar effects of its extract at three different concentration i.e., low (12.5 g MLE in 100 mL water), medium (25 g MLE in 100 mL water) and high (50 g MLE in 100 mL water) on radish and bean (25 mL per plant). It was reported that medium level of MLE was more effective than other treatments. There was an increase of 94% in radish and 65% in bean because of MLE application.

Lab experimentation had shown that moringa spray had a wide range of beneficial effects on plant crops. Effects of spray indicated accelerated growth of young plants. Plants were firmer, more resistant to pests and disease, longer life-span, heavier roots, stems and leaves, produced more fruit, larger fruit, increase in yield 20-35% even if a fraction of these results could be reproduced in the field it could be a great help in increasing food supplies for millions of hungry people (Foidle *et al*., 2001).

MLE Research at Faisalabad

Wheat: MLE was used as foliar application in wheat under field conditions. An increase of 10.73, 6.00, 10.70 and 4.00% was seen in 1000 grain weight, biological yield, grain yield and harvest index respectively, when crop was sprayed with MLE at tillering + jointing + booting + heading. MLE spray only at heading gave 6.84, 3.17, 6.80 and 3.51% more 1000-grain weight, biological yield, grain yield and harvest index respectively, as compared to control. MLE extended the seasonal leaf area duration (SLAD) by 16.41 and 11.48% over control when applied at all growth stages and single spray at heading, respectively. The foliar MLE spray delayed the crop maturity, extent SLAD and grain filling period thereby leading to greater seed and biological yields in late sown wheat (Yasmeen *et al.,* 2011). In another study wheat seeds primed with moringa leaf extract gave average grain yield of 2356 kg/ha significantly higher than unprimed (Yasmeen *et al.,* 2012).

MLE also mitigate the salinity effects in wheat. MLE primed wheat seed showed more emergence index, reduction in mean emergence time and took minimum time to attain 50% emergence under moderate salinity. MLE foliar application exhibited larger leaf area in check and moderately saline soil. MLE priming and foliar spray of MLE induced higher leaf total soluble protein and antioxidants i.e., superoxide dismutase, peroxidase and

catalase observed in MLE priming at 8 dS m^{-1}. Among non-enzymatic antioxidants (total phenolic contents & ascorbic acid) MLE foliar spray ranked first under moderate salinity. MLE foliar spray contribute more for yield contributing parameters under normal saline conditions but more contribution was observed from MLE priming in moderately saline conditions. Overall, MLE priming proved a potential tool to induce salinity stress tolerance in wheat and it is much beneficial to use it as a priming agent for various crops (Ali *et al.,* 2011; Yasmeen *et al.,* 2012).

Maize: MLE was used as priming agent in hybrid maize. Seed primed with MLE diluted to 30 times with tap water increased the germination speed and spread and seedling vigor under cool conditions (Noman, 2008; Basra *et al.,* 2011).

High temperature at planting delayed the seedling emergence in control while seed priming treatments resulted in earlier and vigorous seedling stand. Among all the strategies, osmopriming with MLE diluted 30 times reduced mean emergence time (8.967 vs 9.097 d) and increased final emergence (83.33 vs 86.333) under optimum as well late planted conditions as compared to control.

Agronomic and yield related traits were significantly affected by seed priming at both sowing dates. Comparatively reduced days to tasseling (49.00 vs 50.00 d), silking (53.667 vs 55.000 d) while delayed maturity (102.0 vs 100.3 d) were observed by MLE priming. Maximum number of grains rows per cob (34.933 vs 31.500), total kernel rows per cob (14.30 vs 13.63), higher number of grains per cob (1271.0 vs 1114.0) were recorded for MLE priming. Similarly improved biological (66.75 vs 60.53 t ha^{-1}) and economical yield (6.97 vs 6.23 t ha^{-1}) were recorded for osmopriming with MLE under both optimum and delayed planted conditions. Increased yield by MLE priming was attributed to enhanced seedling emergence, chlorophyll contents and cell membrane permeability (Mehboob, 2011). In addition, amongst others, MLE was also greatly helpful in mitigating the drought stress tolerance in maize (Ali *et al.,* 2011).

Rice: Seed priming treatments included viz. hydropriming, osmopriming with KCl, $CaCl_2$ and MLE (diluted to 30 times). Earlier and uniform crop stand, improved yield and quality attributes were recorded by seed priming treatments in direct seeded rice (DSR) with field capacity (FC) and alternate drying and wetting (AWD) conditions. Among the priming treatments, KCl and MLE primed seeds emerged earlier and uniform under DSR-FC and AWD as indicated by reduced E_{50} (2.22 vs 5.55 d) and MET (10.51 vs 11.61 d) and higher EI (222.25 vs 156.06) values. Higher final emergence (FE) (326 vs 209) was also recorded by KCl and MLE priming under both FC and AWD conditions.

Higher agronomic and yield contributing attributes were found for nursery transplanted rice. But altered irrigation supply at FC or AWD also resulted in improved panicle length (23.00 vs 20.5 cm), productive tillers (369 vs 335); biological (14 vs 10.4 t ha^{-1}) and economic yield (2.61 vs 2.14 t ha^{-1}) in MLE followed by $CaCl_2$ priming as compared to control (hydropriming) and other treatments (Kamran, 2011).

Moringa as water purification agent: A billion people across Asia, Africa, and Latin America are estimated to rely on untreated surface water sources for their daily water needs. Of these, some two million are thought to die from diseases caught from contaminated water every year, with the majority of these deaths occurring among children less than five years of age. Powdered seed act as a natural flocculent; able to clarify even the most turbid water Seed powder can be used as a quick and simple method for cleaning dirty water. The powder joins with the solids in the water and sinks to the bottom. This treatment also removes 90% of bacteria contained in water, water purification by flocculation, sedimentation and antibiosis. Using moringa to purify water replaces chemicals such as aluminum sulphate, which are dangerous to people and the environment, and are expensive. Twenty litres of water may be purified by adding 2 g of powder to one cup of clean water pour into a bottle and shake for 5 min. Filter the solution through a clean cloth into the bucket of dirty water that is to be treated. Stir the water quickly for 2 mins and slowly for 10 to 15 min (do not use metal implements). Leave the bucket undisturbed for one h or until the water becomes clear and the impurities have sunk to the bottom. Filter the water through aclean cloth. Boil the water before drinking (Jahn *et al*., 1986; Sutherland,. 1989; Gassenschmidt *et al*., 1995; Kumar & Gopal., 1999).

Moringa Oil

The most stable natural oil: The Romans, Greeks and Egyptians extracted edible oil from the seeds and used it for perfume and skin lotion. In the 19th century, plantations of moringa in the West Indies exported the oil to Europe for perfumes and lubricants for machinery. A study was done in Pakistan to examine the physicochemical characteristics of *M. oleifera* seeds and seed oil from a wild provenance of Pakistan. The moringa seeds harvested from the forests of Kohat district of NWFP exhibited an oil yield of 34.80%. Protein, fiber, moisture and ash contents were 31.65, 7.54, 8.90 and6.53%, respectively. The extracted *M. oleifera* seed oil revealed an iodine value of 68.63; refractive index (40°C), 1.4571; density (24°C), 0.9032 g cm-3; saponification value, 181.4; un-saponifiable matter, 0.74%; acidity (as oleic acid) 0.81% and color (1-in. cell) 1.28 R + 31.00 Y. Determinations of oxidation parameters like induction period {Rancimat 20 L/h, 120°C}, specific extinctions at 232 and 270 nm, peroxide- and p-anisidine values demonstrated a good oxidative stability of the

investigated M. oleifera oil. Tocopherols (α, γ & δ) contents of the oil amounted to 140.5, 63.18 and 61.70 mg kg^{-1}, respectively and were reduced considerably after degumming. The major sterol components of the oil were β sitosterol (46.16%), campestral (17.59%), stigma sterol (18.80%) and Δ5, avenasterol (9.26%). The wild M. oleifera seed oil was found to contain oleic acid up to 73.22%, followed by palmitic, stearic, behenic and arachidic acids 6.45, 5.50, 6.16 and 4.08%, respectively and fell in the category of high oleic oils. The results of different quality attributes of M. oleifera oil from a wild provenance of Pakistan reveal that it could be employed for edible and commerce (Dahot & Memon, 1987; Anwar & Bhanger, 2003; Anwar *et al.,* 2005; Monica, 2005; Farooq & Rashid, 2007).

A potential source of biodiesel: Moringa seeds contain 30-40% oil that is high in oleic acid. The meal yields about 61% protein. "The data on the oil quality is excellent," "It's better than sunflower oil." biodiesel made from moringa has better oxidative stability than biodiesel made with most other feed stocks (Rashid *et al.,* 2008). *M. oleifera* oil has a high content of oleic acid (>70%) with saturated fatty acids comprising most of the remaining fatty acid profile The methyl esters (biodiesel) obtained from this oil exhibit a high octane number of approximately 67, one of the highest found for a biodiesel fuel. *M. oleifera* can produce 1,000 to 2,000 L bio-diesel per ha year. Production starts within a year and the oil cake and leaves are excellent stock feed (Brockman, 2008).

Moringa oil processed as biodiesel has iodine number better than that of regular diesel, indicating fuel stability (Anonymous, 2012). The oil has a octane number indicating good ignition behavior and a cold filter plugging point indicating suitability even in winter. The biodiesel of moringa has higher recovery and quality of oil than other crops which allows for lower cost processing, while producing the highest grade of Biodiesel and Glycerine by-product. The oil from the moringa tree is considered to be a more sustainable biodiesel feedstock than jatropha oil by those who argue that sustainability is better served by feed stocks that can yield both food and fuel.

Jatropha vs moringa: All known species related to Biodiesel concerns are exotic and none of them is indigenous to Pakistan. Oil extraction from Jatropha seed is a costly process as compared to that of moringa. Jatropha was the toast in biofuel oil industry (Kywe & Oo, 2009; Parawira, 2010), until moringa was discovered as better source. Jatropha is a poisonous plant, cause acute Diarrhea etc. and yield to dehydration. The leftover part of seed is like a nuclear waste, and to dispose the waste is another issue. Jatropha have never been recommended to the farmers for Agro-forestry or for range land Jatropha being a poisonous plant may yield to vital damage to livestock especially in range land areas. Jatropha can only be grown under protected areas if at all required for reasons, or to keep the life away as being grown from Delhi to Bombay in India. In contrast, moringa is recommended for Agro-forestry being farmer friendly. It is indigenous plant and can be grown at wide range even in harsh weather conditions. All parts of the tree are highly beneficial with vital income potentials. Moringa is one of the best plants for range management concerns in Pakistan. It is a better source of Biogas as well as Biodiesel. Oil contents (%) are better in moringa seeds as compared to that of Jatropha. Left over waste is also used for Animal feed because of high nutritional value. Control soil erosion and benefits the global warming campaign. Roots are also used to treat even snake bites in Africa etc. Bio mass is of high quality, used as fodder and is a guarantee to increase milk production.

Biogas/biofuel (high bio-mass): Moringa plants (approximately 30 days old) were milled together with water. The fiber was separated by filtration through a mesh with 5 mm pores and the liquid fraction produced was then added to a biogas reactor. With an average feed of 5.7 g of volatile solids the gas production was 580 L of gas per 1 kg of volatile solids. The average methane content of the gas was 81% (Foidle *et al.,* 2001).

Biopesticide: The injudicious use of pesticides for the control of insects has generated a number of biological and environmental hazards and induces resistance. Plants derivatives are effective and alternate sources of fungi toxic chemicals showing promising results. Laboratory to Land transfer of technology for rural farmers. It has been well recognized that some plant-derived insect-control agents could be developed into products suitable for integrated pest management, because they are selective to pests, have no or little harmful action against non-target organisms and the environment, act in many ways on various types of pest complexes and may be applied to the plant in the same way as conventional insecticides. Many plant extracts and essential oils are known to possess ovicidal, repellent and insecticidal activities against various insects. The insecticidal actions of extracts of some are rapid whereas insecticidal actions of some extracts are slower since over 90% mortality was only obtained at 3-4 days after treatment. These plant materials confirm their usefulness as effective insect-control agents in our field study as well. Plantation of common plants-lemon grass, Caltrops, Lantana, lemon leaves, lemon grass and Neem leaf would help in the preparation of Biopesticide. Moringa oil has the potential to be used as Biopesticide (Fahey, 2005).

Bioactive compounds of plant origin are ecologically safe alternative and the plant extracts with complex mixtures of bioactive compounds have been investigated for their insecticidal, repellent and antifeedant properties at the Globe. Oil of the Physic nut, *Jatropha curcas* L. had repellent activity against the termites. *J. curcas* had ant feeding effect, increased

mortality as well as induced reduction in tunneling activity in captotermes vastator. *M. oleifera* leaf powders were effective against both the larvae and adult of *Trogoderma granarium* Everts and showed repellent properties.

Moringa leaf extract is used insect repellent and fungicide. Aqueous Moringa Seed Extract (AMSE) as fungicide to replace the synthetic ones which are currently being used to devise an organic approach. AMSE with Apron Plus (metalaxyl+carboxin+furathiocarb), and distilled water (medium for extraction of moringa seeds). Their results manifested that moringa seed extract was more effective as biofungicide on groundnut seeds. All AMSE concentrations significantly reduced the fungi incidence on groundnut seeds except 1 gL^{-1}. Moreover, AMSE effect reduced fungi incidence as its dose was increased but no significant differences were found in control between the highest concentration of AMSE (20 g L^{-1}) and Apron Plus at the level prescribed by the manufacturer.

Farmer friendly: Moringa is a plant of marginal land and grows best in hot, semi arid tropics and sub tropics. Moringa is a farmer friendly plant and is useful from top to bottom. It is strongly recommended for Agro-forestry and range land areas of Pakistan. Being a deciduous plant, it does not have any negative effect on crops. It is deep rooted and does not compete with crops for nutritional concerns. It does not have any direct competition with food crops as it is an edible source of fuel. It helps to improve organic matter in soil and ultimately the soil fertility. Moringa is also just like an Agro-Based Cottage Industry at farmer's field. It also helps to maintain clean environment in general and at specific niche in particular.

Future of Moringa

Farmers in rural or peri-urban Africa can easily undertake moringa leaf production: Its production creates employment, requires little financial investment and can be cultivated without using chemicals. The keys to a successful farm are pruning the trees to obtain bushy leaf-growth and regular but limited amounts of water and organic manure. By following these recommendations, a moringa plantation can produce leaves in abundance all year-round.

Processing is also an accessible activity that generates income for food processing businesses and rural farmers' associations: Sun drying is an inexpensive, efficient method used to obtain quality results. Milling does not require specific equipment; the mills widely used in Africa are perfectly adapted. Packaging has to be airtight and light proof. The fundamental aspects of processing are hygiene and humidity control to ensure that the leaf powder stays perfectly dry until packaging.

Moringa leaves are an inexpensive source of proteins, vitamins and minerals for developing countries: Dried and milled, moringa leaves are easily stored and used by families who can then add the powder to their daily meals. The powder can also be used by food businesses to enrich their products in nutrients. Moringa leaves can help decrease developing countries' dependence on imported goods, such as vitamin and mineral complexes that ward off nutritional deficiency but are too expensive to be used in a sustainable way.

Moringa is categorized as a leafy vegetable like the leaves of the baobab, manioc, sweet potato, amaranth and hibiscus. These local leafy vegetables, either cultivated or collected, are all highly concentrated in nutrients. Their use had for a long time been shadowed by European vegetables considered more modern, such as cabbage, carrots etc.

Though today, African consumers are showing a rising interest for these leafy vegetables: Not only for their low cost but also for their taste and health benefits (Ramachandran *et al.,* 1980; Oduro *et al.,* 2008). The importance research programmers and NGOs have given these products, before considered outdated, has also contributed to revamping the image of local leafy vegetables. This increase in interest for local foods and culinary traditions is part of a worldwide trend.

The moringa leaf is a nutritionally rich, ecological, economical vegetable available in practically all countries with malnutrition issues. It is therefore essential to develop the production and consumption of this "green super food".

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