



## A review of bioactivity guided medicinal uses and therapeutic potentials of noxious weed (*Alternanthera sessilis*)

Aamir Shehzad<sup>1</sup>, Abdul Qayyum<sup>2</sup>, Rafia Rehman<sup>1</sup>, Farwa Nadeem<sup>1\*</sup> and Muhammad Raffi Shehzad<sup>1</sup>

<sup>1</sup>Department of Chemistry, University of Agriculture, Faisalabad-38040-Pakistan and <sup>2</sup>Department of Chemistry and Molecular Engineering, Zhengzhou University, Zhengzhou 450001, P.R. China

### Abstract

Noxious weed (*Alternanthera sessilis*) is a perennial herb belonging to family Amaranthaceae. It is known to have high nutritional value since ancient times and found native to North America, tropical and subtropical areas and some regions of South America. This herbaceous plant is 1 m tall and its leaves are simple and opposite while flower is bisexual, obviate linear, blate and whitish pink in coloration. This plant can grow in various climatic conditions and number of environmental specifications however optimum growing conditions are warm climate, bright sunlight and appropriate level of humidity. This perennial herb can be upto the depth of 0.2 to 1 m and known to have tap root system while stems are prostrate, creeping and have nodes at the tip. This plant contains appreciable concentration of fats, proteins, carbohydrates, starch, fibres, amino acids, calcium, phosphorous, vitamin A, vitamin C, vitamin B1, vitamin B2 and minerals too. Essential oil of *Alternanthera sessilis* is known to contain methyl propionate, 2,4-dimethyl-3-pentanol, 2-(1-methylpropyl)cyclopentanone, 2,3,4-trimethylpentanoic acid, methyl-2-O-methyl- $\alpha$ -dxylofuranoside, 2,6-dimethyl-7-octen-3-ol, tetrahydro-2,5-dimethoxy furan, 9-heptadecanone, 1-fluorododecane, 1,1-oxybis heptane, 1-chlorooctadecane, octyl ester 2-propenoic acid, 2,4,4,6,6,8,8-heptamethyl-1-nonene, (Z)-7-tetradecene, 2-pentyl-1-heptene, tetracontane-1,40-diol, didodecyl phthalate and 1-fluorododecane. This medicinal plant is used to treat hepatitis, bronchitis, tight chest, lung diseases and asthma owing to anti-diabetic, anti-cancer, anti-ulcer, anti-oxidant, anti-malarial, anti-diarrheal, anti-fungal, prophylactic, anti-microbial, anti-inflammatory and anti-pyretic potentials and non-tropic, wound healing, hepato-protective, hypoglycemic, anti-diarrhoeal, anthelmintic, anti-bacterial and anti-malarial activities.

**Key words:** *Alternanthera sessilis*, perennial herb, bisexual flower, vitamins, essential oil, wound healing potentials, biological activities

Full length article \*Corresponding Author, e-mail: [farwa668@gmail.com](mailto:farwa668@gmail.com)

### 1. Botany

#### 1.1 Introduction

Noxious weed (*Alternanthera sessilis*) is a perennial herb belonging to Amaranthaceae family. It has been used as food since the ancient times [1]. The genus *Alternanthera* contains a range of 80–200 species. The native range of this genus is uncertain but it is stated in few studies that this genus was first grown in North America as well as tropical and sub-tropical areas and open forests of South America [2]. The uncertainty in the exact number of species in genus is largely attributed to variability among the different species of this genus. Variability is mainly due to growth habit, flower colour, chemical composition of leaves and stems and morphology. The process of cross pollination takes place very easily in noxious weed which results in great diversity and variety that has led some authors to classify some portions of the genus again. The plant is

herbaceous, small in size upto 1 m tall, leaves can be opposite, simple, petiole, blate, linear, obviate and flowers are bisexual with different colours ranging from white to pink. Most common varieties of *Alternanthera sessilis* are treated as perennial and sometime annual. In last few decades, demand of noxious weed is increased due to its excessive use in food as well as in medicine which engendered increase in its economic value.

*Alternanthera sessilis* is known by various names in different languages as "Gudrisag" in Hindi, "Ponnagantikura" in Telugu, "Minannani", "ponnannani", "ponnankannikkira" in Malayalam, "Honugonesoppu" in Kannada, "Ponnannkannikkirai" is its name in Tamil. In Malaysia, it is commonly known as "keremak", "pudohrumputaoh" and "serapat" depending upon the local areas. Few other common names of this plant are "water amaranth", "Dwarf Copperleaf", "Sessile Joy weed" and

"Carpet Weed". Many other local names of this plant are used in different parts of the world and in different local areas. Probably the most familiar noxious weed is "Abisrana" whose scientific name is *Alternanthera sessilis* however this has a wide range of varieties and cultivars which vary in flavors, scents and uses. There are over 120 named cultivars available. Popular examples include *Alternanthera sessilis* "narrow leaf cultivars", *Alternanthera sessilis* "Abisrana" and *Alternanthera sessilis* "water amaranth". According to conditions, the leaf size and shape of *Alternanthera sessilis* vary from lanceolate to more ovate. Its growth habit changes greatly from crawling to more upright [3].



Fig 1 Leaves of *Alternanthera sessilis*

### 1.2 History/Origin

*Alternanthera sessilis* is native to Brazil and is a familiar plant in most of the subtropical and tropical areas of the whole world where it has been cultivated for thousands of years. The generic name of *Alternanthera sessilis* takes its origin from ancient Greek words "alternans" which means "alternating" and "anthera" meaning "anther" referring to the alternations of pseudosaminodes and stamens. There are many suggested origins for the word sessilis used for flowers which do not have pedicel. The history of *Alternanthera sessilis* is not certain as it has pan-tropical distribution and evident to found throughout the old world tropics, tropical Africa, Southern Asia, Eastern Asia and Australia. The uncertainty in its native range can be elaborated easily as many Chinese Authors states it as native to China USDA-ARS (2014) lists the native range as china and southern to south eastern Asia. It is enlisted as native to some of islands of pacific oceans and introduced to others. However the most recent studies on genus *Alternanthera sessilis* suggested that this plant originated in South America and from here it was introduced to the old world. *Alternanthera sessilis* finds important place in traditional medical literature and its Tamil name is "ponannkanni-pon aggum knn nee". This herb contains gold according to traditional siddha literatures and therefore it is included in "kaya kalpa" category also along with this it is believed in India that it gives cooling effects to eyes and body. Studies also indicated that it is believed in Tamil Naddo (India) that this plant will cure 96 types of eye diseases, relieves neuritis and its regular use helps to live a disease free and a healthy life. *Alternanthera sessilis* is used as vegetable in South Africa. Sri Lankan believes that *Alternanthera sessilis* possesses a significant amount of fiber, protein and vitamins and they use it several times per week. In Nigeria, it is used in soup and in Congo as a relish. It is also called

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"Matsyakshi" or "fiseyed" as its flower look like the eyes of fish.

### 1.3 Demography/Location

Although *Alternanthera sessilis* grows well in number of environmental and climatic conditions but optimum conditions are found in countries of hot climate having low humidity, bright light and appropriate warmth as major ecological requirements. It is a weed of shady damp soils, roadsides pathways, wastelands, irrigation canals, ditches, dikes, gardens and swamps. It can be found in hydromorphic rice fields in West Africa and Asia and in the following cultivated areas such as maize crops in Nigeria sorghum, millet, maize, cotton, *cassava sativa*, ground nuts and cash crops in Zaire and tobacco along with dry land field crops, pastures and vegetable farms in the Philippines. While it is typically found growing on a variety of wetland habitat including in water upto the depth of one meter. The plant is adapted to both hydric and xeric conditions. This specie can be grown on almost every type of soil and found in low and medium altitude in Philippines. This plant occurs in many countries which include Australia, Bangladesh, Bhutan, Brazil, Cameroon, Chad, China, Ecuador, Egypt, Gambia, India, Kenya, Indonesia, Iran, Nepal, Saudi Arabia, New Zealand, Uganda, Sri Lanka and Zambia [4]. Loamy alkaline soils which have low calcium and high nitrogen is preferred but very dry conditions can also be tolerated.

Under optimum growing conditions this plant flowers from December till March. Absolute figures for noxious weed oil production are difficult to acquire as there are many local growers and producers on small scale operations whose production numbers are not included in national statistics. However there are some rough figures available. The total global production of *Alternanthera sessilis* is estimated to be 50 to 55 tons per year which is currently produced in following countries: India (17 tons/year), Bangladesh (5 tons/year), Brazil (4.5 tons/year), Sri Lanka (4 tons/year), China (3 tons/year), USA (2 tons/year), Argentina (1.5 tons/year), Nigeria (1.5 tons/year), Zambia (0.5 tons/year), Uganda (0.4 tons/year), Saudi Arabia (0.3 tons/year) and Australia (0.2 tons/year). The global statistics for the production of dried noxious weed are hard to obtain. A large amount of world production particular in India and Sri Lanka are not sold internationally as it is generally consumed locally. Major producer country is India while major consumer country is United Kingdom [5].

### 1.4 Botany, Morphology and Ecology

*Alternanthera sessilis* is an annual and perennial herb of 0.2–1 meter height having tap root system. The stems are mostly creeping; prostrate and seldom rooting at the nodes rarely floating or ascending at the tips and slightly hairy with many erect branches. Its leaves are simple, opposite, shortly petiolate, broadly lanceolate to almost linear in shape, 0.6-5 cm long and 0.3-1 cm wide. They are attenuated at the base and the apex is acute to blunt with

entire pilose and inflorescence is dense sessile, silvery white of compress spikes in the leaf axile, perianth segments are equal in length, acute and 1.5–2.5 mm long with a short point. Bracts are ovate, concave, 0.3-1 mm long, white or purplish and have glossy appearance at a green base.



Fig 2 Fresh parts of *Alternanthera sessilis*

Flowers of *Alternanthera sessilis* are bisexual, regular, 5-mer petals free equal, ovata to elliptical upto 2-5 mm long, semen untied to short cup, superior ovary without anthers and strongly compressed one celled style that is usually very short. Fruit of *Alternanthera sessilis* is an obreni indehiscent upto 2 mm long, dark brown in coloration having one seeded dicot seed that is 1 mm long with shiny brown appearance. To complicate matters further there are number of plants outside the genus which has been mistakenly understood as amaranths sessile as Sri Lankan community members living in Australia mistakenly identified it as sessile jawed because of its resemblance with widely consumed leafy vegetable. It is known by different names in different regions of the world. It is known as "mukunuwenna" in England and "dwarf copper" in Brazil. The fruit of this specie is indehiscent and small flattened. They are light sensitive. *Alternanthera sessilis* require warm temperature however the optimum temperature for its growth ranges from 32°C to 40°C. It can also be found in flooded areas and can tolerate dry conditions. It requires soils with pH 4 to 7 and has medium roots with high water requirement.

## 2. Chemistry

Noxious weed is an impressively aromatic plant mainly used as herb and leafy vegetable. Large number of *Alternanthera sessilis* ecotypes has been described on the basis of their taste, flavor and other characteristics. *Alternanthera sessilis* has varied leaf colour from white to pinkish and plant may grow from 0.2 to 1 m depending on the type of species. *Alternanthera sessilis* vary greatly in taste but mostly its flavour has pungent taste. The fragrance of *Alternanthera sessilis* can be attributed to its essential oil present in roots, leaves and stems.

### 2.1 Chemical Composition

*Alternanthera sessilis* contain high amount of fat and brings a good caloric values and proves to be a good source of vitamin A and C and minerals too. Its leaves have dietary fibers (about 12g/100g of dry matter) and incorporations of 75g of this vegetable in the daily life in diabetic patient can significantly reduce blood glucose level. It is used as food but few advocate as it is risky for health if used in extremely high doses because it is contaminated with heavy metals like chromium. Fresh leaves of

*Alternanthera sessilis* contain water 80g/100g, energy 251kJ/mol, protein 4.7g/100g, fat 0.8g/100g and carbohydrate 11.8g/100g. It contains starch 3.2g/100g, amino acid 0.225mg/100g, 2.76mg/100g of vitamin B1, 12.6mg/100g vitamin B2, fiber 2.1mg/100g, calcium 148mg/100g and phosphorus 45mg/100g. It also contains flavonoids and known to possess anti-oxidant properties. Its leaves have carotene and are rich in iron so it is used to cure night blindness. Essential oil obtained from leaves and flowers of *Alternanthera sessilis* have methyl propionate, 2,4-dimethyl-3-pentanol, 2-(1-methylpropyl)cyclopentanone, 2,3,4-trimethylpentanoic acid, methyl-2-O-methyl- $\alpha$ -xylofuranoside, 2,6-dimethyl-7-octen-3-ol, tetrahydro-2,5-dimethoxy furan, 9-heptadecanone, 1-fluorododecane, 1,1-oxybis heptane, 1-chlorooctadecane, octyl ester 2-propenoic acid, 2,4,4,6,6,8,8-heptamethyl-1-nonene, (Z)-7-tetra-decene, 2-pentyl-1-heptene, tetracontane-1,40-diol, didodecyl phthalate and 1-fluorododecane.

### 2.2 Phytochemistry

*Alternanthera sessilis* has an explicit odor because of presence of essential oil or volatile oil which is mainly confined to green leaves. This volatile oil mainly constitutes terpenes and aldehydes. Tannins and flavonoids are also found in *Alternanthera sessilis* which are responsible for its anti-diarrheal activity furthermore some parts also contain carotenoids, triterpenes, steroid, saponins and  $\delta$ -sterol and  $\beta$ -sitosterol. It also has high carotene contents. Noxious weed essential oil is a useful source of natural antioxidants. Several experiments were performed to determine the phytochemicals present in its essential oils. The essential oil of noxious weed can either be extracted from leaves or from its flowers. The essential oil of noxious weed is pale yellow and have strong aromatic odour. Majorly, seven different compounds are found in essential oil of *Alternanthera sessilis* when extracted from flowers and leaves which indicates that essential phytochemicals are evenly distributed throughout the plant body.

These chemical constituents are 3-methyl-2-(2-oxopropyl)furan, 1,1,1,5,5,5-hexa-methyl-3,3-bis[(tri-methyl-silyl)oxy]tri-siloxane, tetra-hydro-2,5-di-methoxy-furan, methyl 2-O-methyl- $\alpha$ -D-xylo-furanoside, 2,3,4-trimethyl-pentanoic acid, 2-(1-methyl-propyl)-cyclopentanone and last one is 1-fluorododecane. The strong anti-oxidant potentials of its essential oil on DPPH radical scavenging activity were mainly attributed to their hydrogen donating capacities. This principle is based on availability of hydrogen radical or electrons in order to neutralize the free radicals of DPPH to form stable diamagnetic molecule. Nevertheless, degree of decolorization indicates the scavenging potentials of concerned molecules in relatively short period of time. This scavenging potential of essential oil of *Alternanthera sessilis* on DPPH can be due to their ability to donate hydrogen which resultantly reduces the violet colour of free radical of DPPH to pale yellow due to

binding of hydrogen with DPPH. Results of the anti-radical activities of essential oil of leaves and flowers are usually represented by IC50 which indicates the effective concentration that is needed to scavenge about 50% DPPH of sample solution. The chemical characterization of essential oil of *Alternanthera sessilis* showed that it constitutes significant amount of esters, fatty acids, ketones, diterpenes and oxygenated sesquiterpenes.

Table 1 Fatty acid composition of essential of *Alternanthera sessilis*

Fatty Acid	Percentage
Myristic Acid	3.9
Palmitic Acid	16.9
Stearic Acid	5.9
Oleic Acid	26.0
Linoleic Acid	25.2
Ricinoleic Acid	22.1

### 3. Post-Harvest Technology

*Alternanthera sessilis* is a wild weed that is generally not cultivated. It shows rapid growth in shady and moist places. It can easily be propagated by seed and by rooted stem parts. The average number of seeds per plant is about 2000. It is cultivated only on very small scale; however the best harvesting time is in morning after evaporation of dew. It has been observed that the essential oil and plant extract show good activity if cultivated in morning. It can grow in various fields and different soil conditions so there is contradiction in literature about its best harvesting conditions. The fresh leaves of *Alternanthera sessilis* are known to contain higher concentrations of vitamins and have flavor complexity and intensity which is lost in drier leaves. It can be stored for longer times and can be stored for six months. While dry leaves should not be shredded or broken in order to prevent the loss of vitamins and essential oil. The *Alternanthera sessilis* leaves should be dried in a shady place because in case of sun drying, it would loss vitamins and essential oil contents. The 1-methylcyclopropene(1-MCP) is also considered as an important solution to increase the post-harvest life of *Alternanthera sessilis* [6].

#### 3.1 Processing

*Alternanthera sessilis* like other herbal plants is being consumed in variety of ways for various purposes. In addition to its fresh leaves, other common processed forms of noxious weed include whole dry leaves, powdered leaves and extracted essential oil. Whole plant or dried leaves can be stored to be used for extended times beyond its shelf life. It is also traditionally stored in form of oil concentrates. Noxious weed is conventionally dried by hanging washed bundles in dry but in shady places. Noxious weed should be dried immediately after harvesting in order to prevent the oxidation and also because of the reason that they darken if exposed to open air for long period of time. Drying should be done at temperature ranging between 32-40°C to avoid

the loss of vitamin C, vitamin A and other volatile compounds. Its dried form can be stored upto 6 months if protected from light and moisture. Essential oil can be extracted from two parts of noxious weed either it can be extracted from leaves or collected from flower. The essential oil can also be collected from dry aerial parts by hydro-distillation process [7]. It is easy to harvest as after sowing for one time it can be harvested four times and it is being practiced in many parts of the tropical and sub-tropical regions especially in India and Sri Lanka [8].

#### 3.2 Value Addition

The *Alternanthera sessilis* is extensively used as local medicinal plant to treat the lung diseases, asthma, bronchitis, chest tightness and hepatitis. The shoots and leaves of this plant are boiled and taken as potential anti-hypertensive medicine in various regions all over the world. Leaves of *Alternanthera sessilis* are sometimes fried with ghee and applied on eyes to treat many eye related infections. This medicated oil is also used during bathing to give cooling effects to different body parts and specially eyes. It helps to treat halitosis, piles, 96 different eye diseases and neuritis. Dried plant of *Alternanthera sessilis* is used to cure skin infections and to purify blood. It alleviates pain and reduces hyperglycemia too. Its leaves can be used to make salad and even its flowers can be used for making salad. The use of *Alternanthera sessilis* is common in both ways, as it is being used when it is fresh and after drying its use is also in practice. The use of *Alternanthera sessilis* is very common in preparation of soaps in Sri Lanka. It can also be stored for longer time but after drying only. Flowers, leaves and tender stems of *Alternanthera sessilis* are used as vegetable that acts as diuretic medicine owing to excellent therapeutic potentials. Due to number of medicinal components, this plant is also used to make eye Kajal and hair oils. Red variety of *Alternanthera sessilis* is a common garden hedging plant that is mostly used as culinary medicine [9].

#### 4. Uses

Despite of their low consumption, many herbs contribute significantly towards health as they contain certain mineral compounds and are full of antioxidants. Some herbs also contain anti-diabetic, anti-cancer and anti-ulcer pigments. The use of *Alternanthera sessilis* is beneficial for health but the actual amount of its consumptions to gain health benefits is still not certain. Researchers have not recommended about the precise amount of *Alternanthera sessilis* but this herb has been used traditionally and is being used in modern era for its anti-oxidant potential and anti-malarial and anti-diarrheal activities as it contains high amount of flavonoids and anti-oxidant agents [10]. Along with these components, it is also a good source of dietary fiber and vitamins. It has many applications in food industry and being used as leafy vegetable in tropical and subtropical regions. Its oil contain high amount of anti-oxidant agents and is usually sold at

markets of India and Sri Lanka [11]. *Alternanthera sessilis* can be a good addition to your kitchen as it is very cheap and also has many beneficial uses [12].

#### 4.1 General Uses

*Alternanthera sessilis* has many uses because of its minerals, vitamins and high contents of dietary fiber, flavonoids and carotenoids. *Alternanthera sessilis* finds its important place in traditional medical literature as its Tamil name is "ponankanni-pon aggun knn nee". This herb contains gold according to traditional siddha literatures and therefore it is included in kaya kalpa category also along with this it is believed in India that it gives cooling effects to eyes and body. Studies also indicate that it is believed in Tamil Naddo (India) that this plant will cure 96 types of eye diseases, relieves neuritis and its regular use helps to live a disease free and a healthier life. *Alternanthera sessilis* is used as vegetable in South Africa with this belief that it contains high amount of proteins and fibers. Sri Lankans believe that *Alternanthera sessilis* contains significant amount of fibers, proteins and vitamins so can be used several times per week. In Nigeria, it is used in soup and in Congo as a relish [13]. It is also called "matsyakshi" or "fish eyed" as its flower look like the eyes of fish. *Alternanthera sessilis* has been used as leafy vegetable for cooking since long ago. It is used in a wide range of dishes, sauces and sediments. It can easily be blended with other herbs [4].

#### 4.2 Biomedical Applications

The *Alternanthera sessilis* is widely used to treat fever, skin wounds, dysentery, diarrhea, stomach disorders, blood vomiting, vertigo, headache, leaf sap, neuralgia, hernia, snakebite, hepatitis, chest tightness, asthma, bronchitis and used as galactagogue, ferbifuge, abortifacient and cholagogue. *Alternanthera sessilis* was used for simple stomach disorders, dysentery diarrhoea and plaster for wounded or diseased skin and also used against diarrhea. In India and Senegal, it is used to cure snake bite by grounding its leaf to powder. It is used to treat hepatitis but in mixture with other plants and it is a popular folk medicine in Taiwan. It is also in practice to use to treat lung problems, asthma and bronchitis. In Nigeria it is being used to treat headache [8]. It is used for the treatment of biliousness, dyspepsia and sluggish liver in Sri Lanka. This plant is also used traditionally as cooling, digestive, intellect promoting, in burning sensation, liver disorders, skin diseases, as antipyretic and in children for overall development. Ayurveda and Siddha medical systems consider *Alternanthera sessilis* as Ramayana drug. Traditionally, leaves are used in the treatment of skin disease and fever. It is an effective hepato-protective agent. It is also used for curing indigestion [14].

##### 4.2.1 Anti-Fungal Potentials

The anti-fungal activity of *Alternanthera sessilis* leaf extract, essential oil and their component was studied by agar well diffusion method [15]. The ethanol, methanol and aqueous extract of *Alternanthera sessilis* was tested

against plant pathogen *Cyrtomium falcatum*. The sterile petri plate was used to pour PDA medium and then this medium was solidified in sterile petri plate. By using sterile cotton swabs, the test fungal culture was evenly spread over media. Then by using sterile-cork-borer, wells (6mm) were made in the medium, 200 micro liters of every extract was transferred into separate wells, and plates were incubated at 27°C-30°C for 48-72 hrs. After the incubation, plates were observed for formation of clear incubation zone around well, for indication of presence of anti-fungal activity. *Alternanthera sessilis* showed anti-fungal activity against two strains of fungi, which indicate that *Alternanthera sessilis* has good potential against fungus [16].

##### 4.2.2 Anti-Oxidant Activity

Noxious weed oil is known to have strong anti-oxidant properties. Researches have recently shown that the oil contains potential anti-cancer, anti-viral, anti-microbial and anti-pyretic properties [10]. Anti-oxidants are important to maintain a healthy and balance lifestyle, noxious weeds can prove to be a very important source of these essential chemical compounds [17]. However, despite these reputed properties, it is important to be aware that the leaves of noxious weeds are contaminated with heavy metals like cadmium and lead, so its excessive use can engender health hazards. *Alternanthera sessilis* is used by folk medicinal practitioners of Bangladesh for alleviation of severe pain. Use of stems of noxious weed to reduce high blood glucose levels in diabetic patients and to alleviate pain is in practice. Wounds are major cause of physical disabilities. Noxious weed was found helpful in wound healing. There is extensive diversity in phytochemical constituents of noxious weed. These constituents vary significantly with time, cultivation processes and storage [18].

##### 4.2.3 Prophylactic Agent

Noxious weed (*Alternanthera sessilis*) is being used to treat dysentery, night blindness and stomach disorders. Noxious weed has strong anti-malarial properties [19]. Noxious weed is highly beneficial in healing wounds and cuts [10]. Noxious weed is an excellent source of anti-oxidant agents. The fresh leaves of noxious weed were used to extract essential oil by hydro-distillation and were analyzed by GC-MS to examine their antioxidant ability. The presence of oxygenated sesquiterpenes, diterpenes, ketones, fatty acid and esters was confirmed by analysis of essential oil of noxious weed. The result of their experiments suggested that noxious weed has anti-oxidant property. Anti-oxidant agents which are found in noxious weed helps in maintaining good health and in preventing the chances of heart diseases [20]. The paste of noxious weed is used to cure snake bite and this plant is considered to be useful to cure hernia. Paste of noxious weed is being used to draw out spines or any other objects from the body. Noxious weed is very useful to treat hepatitis, asthma, lung troubles and to stop bleeding [21]. Phytochemical investigation of methanolic extract of roots, leaves and flowers of

*Alternanthera sessilis* showed the presence of high contents of flavonoids. Hence the methanol fraction was used for HPTLC studies to detect and quantify the quercetin in the above mentioned extracts. On analyzing the results, it was revealed that *Alternanthera sessilis* has significant amount of quercetin which is used as prophylactic agent. *Alternanthera sessilis* has the properties essential for wound healing and also is a good source of anti-oxidant agents. This plant had been used to cure malaria. *Alternanthera sessilis* has number of oxidant agents which are beneficial for the prevention of heart diseases. It is also being used as potential source of anti-stress agents [18].

#### 4.2.4 Anti-Cancer Activity

Excessive spread of abnormal cells and uncontrolled growth lead to several deleterious diseases that ultimately lead towards death which is commonly known as cancer. Cancer can be due to internal factors such as mutations, immune conditions and hormones and several external factors like viruses, radiations, chemicals and tobacco that acts together in a sequence to enhance the chances of carcinogenesis. The *Alternanthera sessilis* possesses strong anti-cancer potentials and *Alternanthera sessilis*-assisted-silver-nanoparticles are known to exhibit 100% inhibition of breast cancer in human beings. These nano-particles also possess cytotoxic effects on prostate cancer via apoptotic dependent pathways. Intracellular suicides programme possessing changes in morphology like oxidative stress, cell shrinkage, excessive coiling and biochemical responses that lead towards apoptosis. The reason can be due to interaction of silver-nanoparticles with cellular proteins that leads towards consequent changes in the cells. Otherwise, deionization of silver ions can take place prior to entering the tumor cells because of highly reactive nature and low stability of silver ions. As a result of this experimental investigation, complete apoptosis was evident at 25 $\mu$ l/mL for prostate cancer cells while 100% inhibition in growth was obtained for breast cancer cells. These results showed that anti-proliferative effects of PGAG-AgNPs are mainly dependent on concentration and time of exposure [22].

#### 4.2.5 Anti-Microbial Activity

The anti-microbial agent is biochemical specie that inhibits the growth and kills the microbes. Plant based anti-microbial components are known to have full therapeutic potentials that can serve the actual purpose without showing any side effect that might be associated with synthetic anti-microbials. The anti-microbial effects of ethanolic extracts of noxious weeds were determined by using very effective disc diffusion method and these tests were found effective against *Bacillus subtilis*, *Salmonella typhi*, *Streptococcus pyogenes* and *Proteus vulgaris*. The anti-bacterial activity showed better zone of growth inhibition with respect to standard anti-biotic ampicillin and gentamycin as positive anti-bacterial controls [10].

#### 4.2.6 Anti-Inflammatory Activity

Anti-inflammatory effects of aqueous and ethanolic extracts of *Alternanthera sessilis* were tested on different rats at dose concentration ranging from 200mg/kg to 400mg/kg of body weight using carrageenan-induced-rat-paw model. The consequent results suggested that mode of action of *Alternanthera sessilis* might be similar to prostaglandin synthesis inhibition as described for anti-inflammatory mechanism of Indomethacin in inhibition of inflammatory process induced by carrageenan. These findings were found to be useful in terms of therapeutic potentials for treatment of different types of inflammations. Possible anti-inflammatory effects might be due to cyclooxygenase enzyme inhibition that catalyzes biosynthesis of thromboxane and prostaglandins from arachidonic acid. Phytochemical examinations revealed the presence of sterols in leaf extract of *Alternanthera sessilis* that are responsible for this activity [23].

#### 4.2.7 Anti-Diabetic Activity

Diabetes mellitus is an alarmingly spreading disease all across the globe now-a-days. In a past two decades, explosive global increase in number of cases of diabetes has been evident as an emerging problem. In order to evaluate the possible anti-diabetic activities of *Alternanthera sessilis*, qualitative and quantitative analysis were carried out by using aqueous and alcoholic extracts on both streptozotocin induced and normal rats for screening. Hypoglycemic and anti-diabetic effects were also tested in rats. Results showed that alcoholic extracts of *Alternanthera sessilis* reduced the level of blood glucose from 109.32 to 71.67 and the pronounced effects of these extracts started appearing after 4 hours and continued till 12 hours. Results of whole study clearly indicated that aqueous and alcoholic extracts possess enough potential to reduce blood glucose level in diabetic induced rats that are quite encouraging outcomes. Further investigations revealed that glycosides, phytosterols and triterpenoids are mainly responsible for this activity. However, alcoholic extracts are quite more effective in comparison with aqueous extracts [24].

#### 4.2.8 Anti-Pyretic Activity

The anti-pyretic effects of the ethanolic extracts of leaves of *Alternanthera sessilis* were determined through experimentation on albino rats. These ethanolic extracts when applied at the dose concentration ranging from 200 mg/kg to 400 mg/kg of body weight, showed significant reduction in normal body temperature whereas yeast proved elevated temperature in a dose dependent manner when compared with standard anti-pyretic agent. Significant reduction in yeast provoked increased temperature of tested animals by these extracts that are expected to be due to presence of lupeol and  $\beta$ -sterols.

#### 4.2.9 Non-Tropic Activity

Memory enhancing effect or non-tropic potentials of leaves of this plant was determined through experimentation on rats. Methanolic extracts of leaves when administered to adult Swiss Albino Wistar mice at the dose

concentration of 100 mg/kg of body weight showed very positive response in comparison with standard drugs [25].

#### 4.2.10 Anti-Oxidant Activity

The anti-oxidant is a molecule which potentially inhibits the oxidation of various other molecules. Oxidation is basically a chemical reaction that produces free radicals resulting in the continuation of chain reactions that can significantly damage the cells. Some anti-oxidants like ascorbic acid or thiols have ability to terminate the chain reactions. *Alternanthera sessilis* leaves were used to determine the anti-oxidant effect in rat liver and kidney. The animals were fed with *Alternanthera sessilis* leaf extract alone and with leaf extract in combination with carbon tetrachloride (CCl<sub>4</sub>) and a positive control group fed with standard anti-oxidant, silymarin. The activities of enzymatic anti-oxidant like CAT, SOD, Px, GST and GR were assayed. The extent of LPO and free radical scavenging effects of the leaves were also studied. Results showed significant increase in enzyme activity in rats fed with plant leaf extract alone with a relatively lower value by a group treated with leaf extract in combination with CCl<sub>4</sub>. The results showed that *Alternanthera sessilis* leaves possess potent anti-oxidant activity. This was also compared with groups fed with alcohol and alcohol in combination with carbon tetrachloride, which showed a much lower scavenging activity due to oxidative stress induced and also due to the absence of plant extract to combat this damage [20].

#### 4.2.11 Wound Healing Activities

Chloroformic extracts of leaves of *Alternanthera sessilis* are known to have strong wound healing potentials when administered at the dose concentration of 200µg/mL in experimental animals. The contraction of wound area at 16<sup>th</sup> day of drug administration was examined. Results showed that time for epithelization in 16<sup>th</sup> day and scar area after full epithelization was less than 0.0008 in excision wound model that strengthened the concept of its wound healing potential. Later on, some phytochemical investigations showed that sterols were responsible for these wound healing activities of leaf extracts [10].

#### 4.2.12 Hepato-Protective Activity

Hepato-protective effects of this plant were studied on three different types of animals along with some chemical constituents such as CCl<sub>4</sub> reduction in glutamate pyruvic transaminase (SGPT) and serum glutamate oxaloacetic transaminase (SGOT) levels which were observed at every 24 hours after administration of hepatotoxins. These serological observations were also confirmed by number of histopathological examinations. Results of these experimental studies showed that hepato-protective effects of this plant are very useful for liver injuries when applied by using different mechanisms [21].

#### 4.2.13 Anti-Ulcer Activity

Ethanollic extracts of this plant was also analyzed to determine the anti-ulcer potentials in different model rats

suffering from severe ulceration including aspirin induced, pylorus ligation and cold-restraint stress-induced gastric lesions in rats. Some parameters such as gastric volume secretions, free acidity, pH, total acidity, index of ulceration and percentage inhibition of gastric ulcers were also assessed in pylorus ligation model rats while in case of cold resistant stress and aspirin resistant stress, only percentage inhibition and ulcer index was determined. Famotidine at the dose concentration of 20mg/kg of body weight was used as a reference drug that exhibited significant results. Results of entire study concluded that these anti-ulcer potentials are mainly attributed to the presence of different phytochemicals that are still unknown [26].

#### 4.2.14 Hypoglycemic Activity

Hypoglycemic activity of *Alternanthera sessilis* was determined by performing experiments on Albino Wistar rats weighing between 100-150 g. Albino rats were housed under standard environmental conditions and were divided into three groups. The first group of animals was given the dose of 0.2 ml volume of Tween-20 while other groups of animals were treated with 200 mg/kg body weight of extract and 90 µg/kg body weight Glibenclamide mixed with the Tween-20 by single oral administration. At 0h blood samples were collected from tail vein before drug administration to estimate fasting blood glucose. Blood samples were collected at 0.5, 1, 2, 4, 8, 12, 18 and 24<sup>th</sup> h after administration of extract, Glibenclamide, solvent and glucose and results were estimated. The significant hypoglycemic activity was shown by the extract of *Alternanthera sessilis* in comparison to control and standard. The statistical analysis revealed that all the values were significant at 5% significance level (P<0.05). The results further indicate the efficacy of alcoholic and aqueous extracts of the plant [12].

#### 4.2.15 Anti-Diarrhoeal Property

Albino Swiss mice weighing between 20-30g of either sex were used for determination of anti-diarrheal property of *Alternanthera sessilis*. All the experiments were performed by them in the morning time according to the guidelines for the care of laboratory animals and the ethical guidelines for the investigation of experimental pain in conscious animals. The aqueous extract of *Alternanthera sessilis* showed significant anti-diarrhoeal activity (P<0.01) due to its inhibitory effect both on gastrointestinal propulsion and fluid secretion. Aqueous extract of *Alternanthera sessilis* showed significant anti-diarrheal activity (P<0.01) against castor oil induced diarrhoea in mice. The inhibitory effect of extract justified the use of the plant as a non-specific anti-diarrheal agent in folk system of medicine. This anti-diarrhoeal property was the result of tannins and flavonoids which were found to be present in *Alternanthera sessilis* [19].

#### 4.2.16 Anthelmintic Activity

The helminthes of cattle is a matter of great concern in tropical and subtropical regions that generally

results in reduced productivity, increased rate of mortality, loss of weight and decrease in amount of wool and meat by lowering appetite, retarding the growth and impairing the digestive efficiency. Various extracts of the *Alternanthera sessilis* exhibited concentration dependent anthelmintic activities when tested on live nematodes. These results were found to be statistically significant ( $P < 0.05$ ). Highest activity was observed after 4 h when the concentration of 50 mg/ml was applied. Present experimental investigation revealed that EA possesses rather stronger anthelmintic potentials and was the major responsible constituent for observed activity of ASE. These studies revealed the potential of *Alternanthera sessilis* against anthelmintic [27].

#### 4.2.17 Anti-Bacterial Activity

By using disc diffusion assay method, anti-bacterial activity of *Alternanthera sessilis* was determined against twelve different bacteria. Both type of bacteria i.e. gram positive and gram negative bacteria were examined in these studies. The leafy extract of *Alternanthera sessilis* showed significant anti-bacterial activity (zone of inhibition=6-21 mm). The result showed that *Alternanthera sessilis* has good potential to act as anti-bacterial agent [28].

#### 4.2.18 Anti-Malarial Activity

Malarial diseases are one of the most devastating causes of high mortality and morbidity in different regions all over the world. Malaria can preferably be transmitted through the bite of female anopheles mosquito. In Africa, mosquito "*Anopheles arabiensis*" is one of the leading vectors of malaria. Methanolic and aqueous extracts of *Alternanthera sessilis* were tested for insecticidal activity, including adulticidal and larvicidal potentials against adult female mosquito, *Anopheles arabiensis*. The extracts of *Alternanthera sessilis* were found to be ineffective and failed to satisfy the criteria set by the WHO. In these tests, for repellency against *Anopheles arabiensis*, all the tested methanolic and aqueous plant extracts except those of *Alternanthera sessilis* repelled 80-100% of mosquitoes [29].

#### 4.2.19 Hematinic Activity

Hematinic potentials of *Alternanthera sessilis* was investigated by monitoring the change in hemoglobin and serum ferritin levels of rats and mice. Tested animals were induced of anemia after which different doses of test samples were administered orally for 14 days. The standard drug ferrous sulfate was used during experiment which served as the positive control and water as the negative control. Results of entire investigation indicated significant increase in serum ferrite level along with hemoglobin level [30].

### 5. Summary

Noxious weed (*Alternanthera sessilis*) is a perennial herb belonging to Amaranthaceae family. It has been found all over the world and its cultivation is also in practice in many parts of tropical and sub-tropical region and has been used for essential oil applications, traditional medicine and as leafy vegetable since ancient times. The Shehzad et. al., 2018

extent of each of these chemical constituents varies depending on type of species as well as cultivation conditions such as soil type weather and other horticulture practices. Noxious weed is an essential component of several industries that range from food to pharmaceutical products but along with these beneficial uses, its leaves are contaminated with heavy metals like chromium and cadmium etc. So its excessive use can be toxic for health further research on noxious weed is needed to maximize its per hector yield, optimum preservation and oil extraction methods, particularly in developing countries where noxious weed leaf and flower harvesting and post-harvest processing methods are much more similar to traditional methods.

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