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UTILIZATION OF WEEDS AS BIOLOGICAL RESOURCES AND AS A MANAGEMENT TOOL

Kil-Ung Kim[1] and Dong-Hyun Shin[1]

ABSTRACT

Although weeds are considered undesirable or troublesome plants, many weeds and their relatives, occurring on mountains, disturbed habitat and on arable lands, are very important for us to use as good natural resources. In Korea, native plants, and/or weeds were found to belong 185 plant families, and included 1,065 genera, and 4,596 species in total. Some of these weeds have medicinal uses; others are edible, and still others possess dyeing properties. Colonizing plants can be used to remove environmentalcontaminants, raw materials for ethanol bio-fuel, and as sources for phyto-chemicals and allelopathic chemicals. Allelopathic phenomena may also be increasingly used in the field, for weed suppression. Recent reviews indicate extensive and similar uses of weeds, which have been reported from many Asian countries. Of the major avenues of utilization, the use of colonizing plants to remove environmental pollutants, their use as bio-fuel sources and the exploitation of their allelopathic potential are all receiving significant attention in the Asia-Pacific Region. Weeds or their relatives have a variety of genetic diversity from which useful genetic resources, such as a gene(s) for functional substances can be derived and introduced into cultivating crops. Some plants, such as wild oat (Avena fatua L.) and spotted knapweed (Centaurea maculosa Lam.) have a strong allelopathic potential or parasitic ability by which neighboring plants are completely controlled. Strategies for isolating and characterizing functional substances could be employed for economic exploitation of weeds. Genes coding for the functional substances should be cloned and introduced into cultivating crops for developing a new genotype. Future efforts in Weed Science should not ignore the various possibilities of utilization of weeds or their relatives as biological resources increased exploitation of colonizing species will be a useful management tool for some species, which are currently considered problematic.

Key words: functional substances, biological resources, exploitation of weeds.

INTRODUCTION

A weed is commonly defined as a plant growing where it is not desired. Weed species interfere with our endeavors, such as agriculture or animal farming, recreational pursuits, including

[1]Kyungpook National University, Daegu, Korea
Corresponding author's email: kukim@knu.ac.kr

gardening, transport, bush walking and water sports etc. There are a large number of publications including books and review papers that have shown the loss of agricultural production caused by 'weeds' or 'invasive species', and the threats posed by such species to biodiversity.

Globally, the utilization of weeds has been patchy over the past five decades. Nevertheless, there is a renewed interest in focusing on utilization of weeds in productive ways, so that people may benefit from an aspect that has been largely ignored (Chandrasena, 2007). Weeds have been used for long time as sources of food, fiber, dye, medicines, animal fodder, a remover of water pollutants, green manure, materials for slope management, mulches, ornamental plants, handicraft, broomstick, feeding honey bee, roof thatching and allelopathic plant. Among these, the most significant uses have been found on weeds as sources of edible and medicinal plants, and aquatic weeds to remove pollutants, with plant residues largely utilized as mulches etc. Dandelion (*Taraxacum mongolicum* Hand.-Mazz.) causes a risk in agricultural production, while this weed is used for food and therapeutic purpose. This means that most of weed species have a negative effect on crop production, but they have also beneficial aspects.

In this regard, there is a relevant review publication on weed utilization in the Asian-Pacific region edited by Kim *et al.* (2007), covering ten different countries. An article contributed by Chandrasena (2007) in this publication seems to be a lead review essay, which helps us understand the utilization of weeds.

The present paper present a brief overview of the uses of weeds as bio-resources in the Asian-Pacific Region, based on contributions from the above ten countries in the publication on 'Utility of Weeds and their Relatives as Resources'.

Weeds as Biological Resources

Edible Weeds

Edible weed species reported in different countries in the Asian-Pacific region were as follows: 59 weed species in 45 families in Thailand (Maneechote, 2007), about 34 weed species in Malaysia (Bakar, 2007), about 37 weed species in Sri Lanka (Abeysekera and Herath, 2007), about 131 weed species in Japan (Morita 2007) and about 150 weed species in China (Li and Qiang, 2007). Those who are interested in the use of weed species as edible plants may refer to the assay of Morita (2007), in which detailed plant parts for their utilization were presented.

Many of those weed species listed overlapped in different countries. There are numerous accounts on the use of weeds and their relatives as vegetables among Asians. When shortage of food becomes

severe from this day forward, weeds and their relatives will serve as supplement of the staple foods. Li and Qiang (2007) reminded of 59 common weed species which have been popular as wild vegetables in China. For instance, a pigweed, *Amaranthus* spp. in the Amaranthacea family occurs in upland at both temperate and tropical region and is a very well known edible plant for all the Asians. This plant species is commonly considered as a weed, but is directly harvested in the wild for vegetable or is cultivated as a vegetable crop. There are many other examples of the use of common noxious weed species, such as common purslane (*Portulaca oleracea* L.) and common lambsquarters (*Chenopodium album* L.), and prostrate knotweed (*Polygonum aviculare* L.) etc. which are all used as vegetable sources. Parts of weeds which are utilized are mostly young leaves, shoots and whole plants, but flowers, roots, bulbs and tubers are rarely used.

Medicinal Plants

There are numerous accounts on weed species used as medicinal purpose in the Asian-Pacific region. There were, as weeds being used for medicinal purpose, about 40 species in Malaysia (Bakar, 2007), 200 weed species in Sri Lanka (Joseph 2001), about 120 weed species in India (Naidu *et al.* 2005), 43 weed species in 29 families in Thailand (Maneechote, 2007), 127 weed species for ethno-medicinal use in Pakistan (Hamayun and Lee, 2007), 400 weed species in China (Qiang, 2002) and 132 grasses, including weeds in Korea (Lee *et al*., 2007). Just like edible weeds, many of them from different countries, belong to the same genus.

Weeds are highly valued in traditional medicine systems and have been used by indigenous communities for curing different ailments for thousands of years. Most of weeds have been known to posses therapeutic properties and the pertinent traditional knowledge was transferred orally through generations. It is clear that new pharmaceuticals are like to be found in colonizing plants, and as Stepp (2004) suggested, weeds need to be given more attention as potential sources of phytomedicines. This is important because 80% of the world population continue to rely mainly on traditional medicines for their health care (Gurib-Fakim, 2006).

Purple Nutsedge (*Cyperus rotundus* L.) which is one of world worst weeds listed by Holm *et al.* (1977), is used as medicinal plant in Asia. Tubers of this weed are used to cure body ailment such as fever, headache, sores, vomiting, eye inflammation and skin itching etc. (Hamayun & Lee, 2007; Maneechote, 2007). Seeds of cocklebur (*Xanthium strumarium* L.), roots of curly dock (*Rumex crispus* L.) and whole plants of common dayflower (*Commelina communis* L.) are also used for medicinal purpose.

There are numerous uses of weed species as herbal medicines to cure a host of body ailments and diseases in the Asian-Pacific region. However, more research is needed to verify the active chemicals and how herbal medicines, based on weeds, can cure human diseases. Thus, investigating therapeutically or allelopathically active compounds in colonizing plants presents a scientific challengeElucidating the chemistry of these bio-active compounds will led to identifying opportunities for future development of medicines (Schűtz *et al*, 2006).

Restoration Of Polluted Environments

Many studies have shown that weed species had high accumulating abilities of heavy metals and so were used to remove heavy metals from polluted environment. Weed species such as black nightshade (*Solanum nigrum* L.) and horse weed (*Conyza canadensis* L.) have high endurance to Cd and Cd-Pb-Cu-Zn complex contamination, and also have high accumulating ability of Cd (Wei *et al*. 2003). Another species, giant ragweed (*Ambrosia trifida* L.) accumulates Cd and Zn in its tissue at levels that are two-to-three times greater than other plant species, suggesting the use of this plant for remediation of heavy metal-polluted soils (Peles *et al*., 1998).

Some other species *Pteris vita* L. (Chen *et al.*, 2002), *Sedium alfredii* (Yang *et al*. 2002) and *Viola baoshanensis* (Liu *et al.,* 2002) have high ability to accumulate Zn, Cd and arsenich. Another weed species, *Xanthium sibiricum* is highly capable of bio-accumulating mineral substance such as Mn, Cu, B, P. and Pb (Li *et al*., 2005). An exotic weed, water hyacinth absorbed a large amount of Cl^- and PO_4^{3-} and heavy metals such as Cr, Pb, Hg, Ti, Ag, Co and Sr from polluted water (Wu, 2003).

Despite water hyacinth causing major problems in some parts of the world, the risk of using it in closed and controlled treatment ponds in areas where the plant is already present might be acceptable (Ebel *et al*., 2007). For further information, please refer to the articles presented by Li and Qiang (2007) and Ebel *et al*. (2007).

In Korea, common reed [*Phragimites australis* (Cav.) Trin ex Steud], narrowleaf cattail (*Typha angustifolia* L.), duck weed (*Lemna aequinoctialis* Welw.) and eared watermoss (*Salvinia auriculata* Aublet) etc. are used for cleaning polluted water.

Weeds Used As Dye

Plant species used for dyeing are not numerous as the edible plant and medicinal herbs. In Korea, the following species such as Japanese mugwort (*Artemesia princes* Pampan.), safflower (*Carthamus tinctouris* L.), American false daisy [*Eclipta prostrata* (L.) L.], annual fleabane [*Erigeron annuus* (L.) Pers.], and indigo

(*Polygonum tinctorium* L.) etc. are known to produce natural dyes (Lee *et al.* 2007).

Natural dyeing materials have received a great attention in Korea because people prefer a natural dye than artificial one. Indigo plant is a good example, which is commercially used as a natural source of dyes for staining clothes. This is why this plant species is regarded as one of industrial crops.

OTHER USES OF WEEDS

Weeds as fodders and animal feeds

Due to increasing demand of livestock production, it needs an increase of animal feeds. Graminaceous weed species are by and large used as herbage or fodders for cattle, goats and ducks etc. Species from the genera *Axonopus, Brachiaria, Digitaria, Leersia, Leptochloa, Paspalum* and *Pennisetum* are fairly commonly used by farmers as fodders for their animals in Malaysia.

Sedges are not favored as animal fodders. Some broadleaf weeds like *Asystasia gangetica*, water hyacinth and *Limnocharis flava* (L.) Buch. etc. are served as animal fodders in Malaysia (Bakar 2007). The latter two species are normally fed to pigs. The comparative nutritive values of some of these species were presented in the assay of Bakar (2007). There are many other similar uses of weeds as fodders or animal feeds in various countries in Asia.

Weeds used as green manure and compost

Weeds can be used as composting materials, without wasting them. Conversion of green waste-leaves, branches and grass-clippings from parks, garden, roadsides and home to composts is common in Asian-pacific farmers. Colonizing species make up a substantial part of this material.

Although composting is a valuable practice, ineffective commercial composting has been implicated in spread of certain weeds through seeds and propagules, which are not dead (Chandrasena, 2007). Thus, it needs very careful preparation for compost or green manure not to disseminate undesirable seeds or propagules.

Farmers have used water hyacinth, *Sanvinta molesta* D.S. Mitchell and *Parenthium hysterophorus* L.for composting material in India and various weed species, such as water hyacinth, *Ipomoea cornea* Jacq*., Chromolaena odorata* (L.) H.M. King & B.L. Robinson (Kathiresan, 2007) and *Crotalaria juncea, Sesbania rostrata and Croton laccifera* (Abeysekera *et al.*, 2001) have used for green manure materials. Many research data show that combinations of green manure with moderate amount of chemical fertilizer are more effective than sole chemical fertilizer application.

Weeds used as shelter

Some weeds such as cogongrass [*Imperata cylindrica* (L.) P. Beauv.] and *Vetiveria zizanoids* (L.) Nash can be used as materials for covering roof of shelter for human and animals (Abeysekera and Herath, 2007). Some other grasses are also used for the same purpose for shelter.

Weeds used as making handicraft

Many weeds of Cyperaceae family such as *Cyperus pilosus* Vahl, *Scirpus articulatus* L. and *Scirpus grossus* L.f. are used for making mats, hats, carpet and souvenirs in Sri Lanka (Abeysekera and Herath 2007). These handicrafts can give an additional income to farmers of Sri Lanka. Utilization of these weeds is an indirect method of weed control while providing additional income to Asian farmers.

Bio-energy

The dry stem and leaves of many weeds can be directly burned as fuel. The alien weed species *Eupatorium adenophorum* L. and water hyacinth (Zhang, 1996) can be used to produce methane, and *Helianthus tuberosus* (Jiang and Zhang, 2003) for ethanol. In addition, silvergrass (*Miscanthus sinensis* Anderss) and common reed can be used to produce bio-energy.

Genetic resources and gene pool

Wild soybean (*Glycine soja* Siebold & Zucc.) and wild rice (*Oryza rufipogon* Griff.) are excellent genetic resources which can be used for varietal improvement tolerant to adverse environment and insect-diseases. Wild soybean has been used for improvement on seed quality (functional substances: isoflavon content) of the recommended variety. Parasitic plant, *Tryphysaria versicolor* can be used for determining allelopathic potential through haustorium formation.

Weeds Used as Mananagement Tools

Allelopathy

Allelopathy is defined as 'any direct or indirect harmful or beneficial effect by one plant to another through the production of chemical compounds that escape into the environment' (Rice, 1984). It is known that many weeds exhibit or assumed to exhibit allelopathy. Most allelopathic weeds are economically destructive to crop production and attempts to control them have met with limited success.

However, a few allelopathic weeds and their allelochemicals can be used for pest management and control in agricultural ecosystems or employed for biorational pesticides (Duke *et al*., 2000; Kong *et al*., 2006; Macias *et al.,* 2007). Despite this, relatively little attention has been paid to how allelopathic weeds and their allelochemicals could be potentially utilized as an important part of pest management and control in agricultural systems (Kong, 2010).

The use of allelopathic plant mulches for ecological pest management and control has received a great attention (Hong *et al*. 2004). Allelopathic weeds may be used as covering chips or intercropping species for pathogen and weed reduction (Xuan *et al.,* 2005).

The mulches of a number of allelopathic weeds such as *Ageratum conyzoides*, *Bidens pilosa*, *Euphorbia hirta*, *Tephrosia candida*, *Lencaena glauca, Morus alba*, wild oat and spotted knapweed might be useful as an alternative materials for biological control and for the reduction of herbicide dose that are used in paddy fields. The use of these allelopathic weeds as mulches promoted rice growth and yield, and greatly reduced paddy weed growth at dose of 2 t ha^{-1}. Particularly, two species such as *B. pilosa* and *T. candida* were the most effective candidates, attaining over 80% weed control and increasing rice yield by 20% (Hong *et al*., 2004; Khanh *et al*., 2005).

However, utilization of allelopathic weed mulches in practice might be effective under the careful integration of cultural management and herbicides. The use of dry powder from allelopathic weeds such as *Parthenium hysterophorus*, *Coleus amboinicus*, and *Tragia biflora* was also effective to control an aquatic weed, water hyacinth (Kathiresan, 2000).

Allelopathic weeds can biosynthesize a wide variety of phytochemicals that have relatively broad-spectrum activity and some are known to provide defense mechanisms against other plant competitors and to attack microbes or insects and animal predators. Thus, the research and development of allelochemicals that have been derived from allelopathic weeds as sources of natural herbicides have been carried out throughout world (Duke *et al.,* 2000; Macias *et al*., 2007).

A recent study on the cases of *Ageratum conyzoides* L., *Ambrosia trifida* L. and *Lantana camera* L., provides examples of allelopathic weeds and use of their allelochemicals that have been incorporated into ecological pest management and control in China (Kong, 2010).

Many studies verified the mechanisms of a self-defense system, including allelopathy in plants. Most plant chemicals associated with allelopathic activity are secondary metabolites from shikimic acid or acetate pathway and the terpenoid pathway. Plants respond to environmental stress through a variety of biochemical reactions, which may provide protection against casual agents. It has been well documented that allelopathic phenolics and terpenoid compounds are increased under stress environment, for example, enhanced UV-B light induces the accumulation of phenylpropanoids and flavonoids in various plant species.

What are allelopathic traits? Morphological characteristics such as early seedling emergence, seedling vigor, fast growth rates that produce a dense canopy, greater plant height, greater root volume and longer growth duration are known to increase the ability of crop competiveness. However, it is not easy to identify morphological traits directly related to allelopathy. If morphological traits or allelochemicals or genes responsible for allelopathic effects are identified, allelopathic traits can be easily incorporated into improved cultivars through breeding techniques available at the present time.

A strategy for isolating and characterizing functional substances could be employed for economic exploitation of weeds. Genes coding for the functional substances should be cloned and introduced into cultivating crops for developing a new genotype. Such efforts will give some fruits of success for utilization of weeds or their relatives as biological resources and as management tool. Allelopathic plants or weeds, can also be used as strongly allelopathic mulches in intercropping as a weed management tool.

CONCLUSION

Weeds are clearly highly successful plants, largely due to characteristics that confer superior colonizing ability and competitiveness. These attributes can be useful in many situation, such as in repairing damaged ecosystems.

It is accepted that in some situations in agricultural fields, there are huge crop losses due to excessive and unmanaged weed growth.. However, as discussed in this essay, Asia-Pacific countries should look at the positive aspects of weeds as well; i.e. their utilization as resources. As indicatedabove, proper utilization of weeds can contribute significantly to enhance the income of the poor farmers, besides giving various other benefits in various ecosystems.

Many weed species have been used for edible and medicinal plant sources. In a use of edible purpose, investigation on nutrition value of such weeds will help their utilization. Weed species which are used for medicinal plants will receive more attention because 80% of the world population continues to rely mainly on traditional medicines for their health care. Studies on verification of chemical component in specific medicinal weeds will give a clue of synthesizing a new medicine.

Many weed species can be used for phytoremediation which uses plants and plant process to remove, degrade, or render harmless hazardous materials, such as nonvolatile hydrocarbons and immobile inorganic matter, including heavy metals present in the soil and ground water. Weed species which help eliminate pollutants from soil and water, can be recommended in required ecosystems.

It needs to utilize abundantly available weed biomass for some useful purpose. Making compost from weeds has a great potential which can be utilized by the poor farmers at very low cost. Efforts should be made to popularize the compost preparing techniques among the farmers, and thus farmers can save money for purchasing inorganic fertilizers.

Some weeds can also be an alternative source of bio-energy. This is an area which should be developed because petroleum is gradually exhausting.

Many woody weeds may be converted into compacted fuel in the form of briquettes (Gunasena and Puspakumara, 2004). Some weeds can be sources of essential oil, gum and dye, and materials for furniture, hand-made paper and thatching etc.

On the other hand, allelopathy can be applicable for management tools in crop production through breeding of allelopathic crops, mulches of allelopathic weeds and making powder from allelopathic weeds. Allelopathy alone is not likely to replace totally other weed control practices because its effectiveness is influenced by many factors. However, marginally reduced use of herbicide over time will be a significant economical benefit to farmers and will also reduce the ecological impact on the environment.

This essay introduces various accounts of weed utilizations. This information can be usable for the poor farmers in the Asian-pacific region. Further studies on weed utilization including wild plants and allelopathy will broaden the horizon of weed science and shed more light on beneficial effects of weeds.

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