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## **Economic Importance of Weeds: A Review**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author KUE designed the structure of the review. Author CBE contributed in the first draft of the work. Author TNO arranged the literature and references. Author CNO did the internal editing. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/APRJ/2019/v3i230063

Editor(s):

(1) Dr. Sheikh Abdul Shakoor, Guru Nanak Dev University, Amritsar, India.

Reviewers:

(1) Gul Hassan, University of Agriculture, Pakistan.

(2) Débora Tomazi Pereira, Federal University of Santa Catarina, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/52647>

**Review Article**

**Received 12 September 2019**

**Accepted 19 November 2019**

**Published 13 December 2019**

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### **ABSTRACT**

Weeds are plants that are unwanted in a given situation and may be harmful, dangerous or economically detrimental. They are responsible for substantial losses of farm production and extensive damage to the environment. Weeds, through competition with other plants, would almost always have deleterious effects on them and can have a lethal effect on livestock through consumption of weeds containing poisonous chemicals in the pasture. Weed invasion has become the most dreaded and deleterious impact of weeds in nature; it adversely affects agriculture, alters the balance of ecological communities, disrupts the natural diversity and interferes in the aesthetic value of the environment. Weeds can interfere in water management, thereby reducing the economic value of water. Weeds, however, besides their deleterious impacts in nature, have many beneficial properties, which include, but not limited to benefits of weeds to companion plants, ethnomedical and ethnopharmaceutical uses of weeds, ethnobotanical uses of wild edible weeds, and the use of weeds as feed for livestock. In the light of myriads of deleterious effects and benefits accompanying weeds, it is suggested that more studies should be carried out on weed control and weed management. Also, further explorations on the potential uses of weeds to man, his environments and livestock should be undertaken.

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*Keywords: Weeds; competition; deleterious effects; beneficial properties; weed invasion.*

## 1. INTRODUCTION

Although some weeds have some beneficial impacts to man, his environment and livestock, weeds are problematic both in agricultural and non-agricultural areas so that they potentially cause economic losses. An indisputable and expensive impact of agricultural practices is the adaptation of weeds to agricultural systems. Weeds are responsible for significant crop yield losses and financial losses in agricultural production in the order of 10% per year worldwide [1]. Weeds interference in crops dates back to the beginning of agriculture, and they have been able to persist, in spite of long term control operations [2]. Weeds compete with other plants for limited resources (mainly nutrients, water and light), and competition can be successful through the use of certain strategies. Chief among these strategies is allelopathy, where secondary compounds inhibit germination and growth of other plants, and, as a chemical defence against herbivory [3].

Weeds can affect animals by providing an inadequate diet or a diet that is unpalatable because of chemical compounds in the weed [4]. They can directly reduce the quality of animal products by affecting milk production and fleece or hide quality. Reproduction performance is affected by toxins that cause abortion or kill animals. Poisonous plants may contain one or more of hundreds of toxins from nearly major chemical groups, including alkaloids, glycosides, saponins, resinoids, oxalates, and nitrates [5].

Despite the negative impacts of weeds both in agricultural and non-agricultural areas, their beneficial impacts on man, his environments and animals cannot be overemphasized. Some beneficial weeds repel insects and other pests through their smell [6]. The recent surge of public interest in medicinal ethnobotany stems perhaps from the exotic association of medicinal weed plants with primary tropical rainforests. The association has been promoted through several popular press books and articles [7] [8]. Weeds are an important source of medicines for indigenous people and have a highly significant over-representation in indigenous pharmacopoeias about other plants [9]. Sometimes weeds can serve for both medicine and food, while some serve as food because of their nutritional contents. The overlapping roles of wild plants as food and medicine have been

discussed by various authors [10]. This review aims to update the literature on weeds by highlighting some of the deleterious impacts and beneficial properties of weeds.

## 2. DELETERIOUS IMPACTS OF WEEDS

### 2.1 Cost of Weeds on Production

The cost of weeds is an important component of every production system. Weeds impose costs on production in two ways; through the reduction in the quality and quantity of the product, and increase in input requirements for weed control. This cost may have economic consequences for the wider community if a large number of farmers are affected, leading to variations in supplies and prices of commodities [11]. The Cooperative Research Centre for Weed Management Systems has estimated the economic loss caused by weed in Australia exceed \$ 3.3 billion annually in terms of reduced productivity and the costs of weed control [12].

Pasture weeds impose costs through a reduction in the amount of pasture available for grazing, reducing stocking rates and therefore annual income. Weeds may also reduce the quality of production through deterioration in the health of animals (from poisonings and injury) and contamination of the products (e.g., vegetable matter in wool and tainting of milk [11]. [13] for example, reports estimates of the economic impacts in Australia of weeds in crops, pastures and public lands. Direct financial losses due to weeds in crops were estimated to be \$ 1013.4 million (including cultivation, herbicides and their application). Indirect losses (resulting from yield losses and product contamination) totalled \$ 855.6 million, giving a total economic loss of \$ 1869 million. The total losses associated with pasture weeds, both direct and indirect, were valued at \$ 971.1 million. In both cases, the indirect costs in terms of losses in productivity exceed the direct costs of weed control. Meanwhile, \$ 6 million were being spent annually on weed control in Florida (USAID p.7). About 2 million of this amount was being spent in the 18-county (then) Central and Southern Florida Flood Control District, allowing the overall benefits estimated for the project to reach 82 million [14].

### 2.2 Competition with Crops

Competition (which represents the negative effect of plant interaction) is the most studied

type of interference between plants [15]. Competition is a biological interaction between at least two plants for limited resources (mainly light, water and nutrients) [16]. Resource limitations can be caused by the unavailability, poor supply, or proximity to neighbouring plants, which ultimately can aggravate an already insufficient resource or create a deficiency where ample resource was available for a single individual [15]. Competition among weeds and crops affects both types of plants; nevertheless, weeds almost always have a deleterious effect on crops [17].

Weed problem occurs when a sufficient weed seed population encounters a favourable environment for weed growth in the presence of a crop that is susceptible to the effects of weed competition (see Fig. 1).

Weed-crop competition can be devastating. The severity of weed competition against crops is related to weed population density (numbers per unit area), the timing of weed emergence relative to the crop, and proportion of resources (light, water, nutrients) consumed by the weeds [18]. This is, according to [19], represented by a triangle called 'weed triangle' (see Fig. 2). This 'weed triangle' is analogous to the crop disease

triangle, consisting of sufficient pathogen inoculums, a favourable environment for the organism's growth, and a disease-susceptible crop.

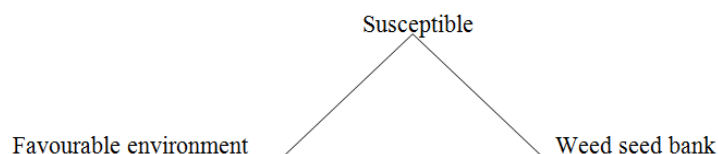
### 2.3 Allelopathy

Weeds affect crops in other ways as well, such as releasing substances that are toxic to the crop, a phenomenon called allelopathy. The production of phytotoxic natural products by weeds is a mechanism by which these species may become successful competitors. The donor plants release allelochemicals into the surrounding environment through leachates, root exudates and volatilization (see Fig. 3) and, hence, accumulation of allelochemicals causes toxicity, affecting crop growth and yield [20]. The weediness of some species that are introduced into new environments may be caused by their production of allelopathic chemicals, which indigenous plants are not yet adapted to.

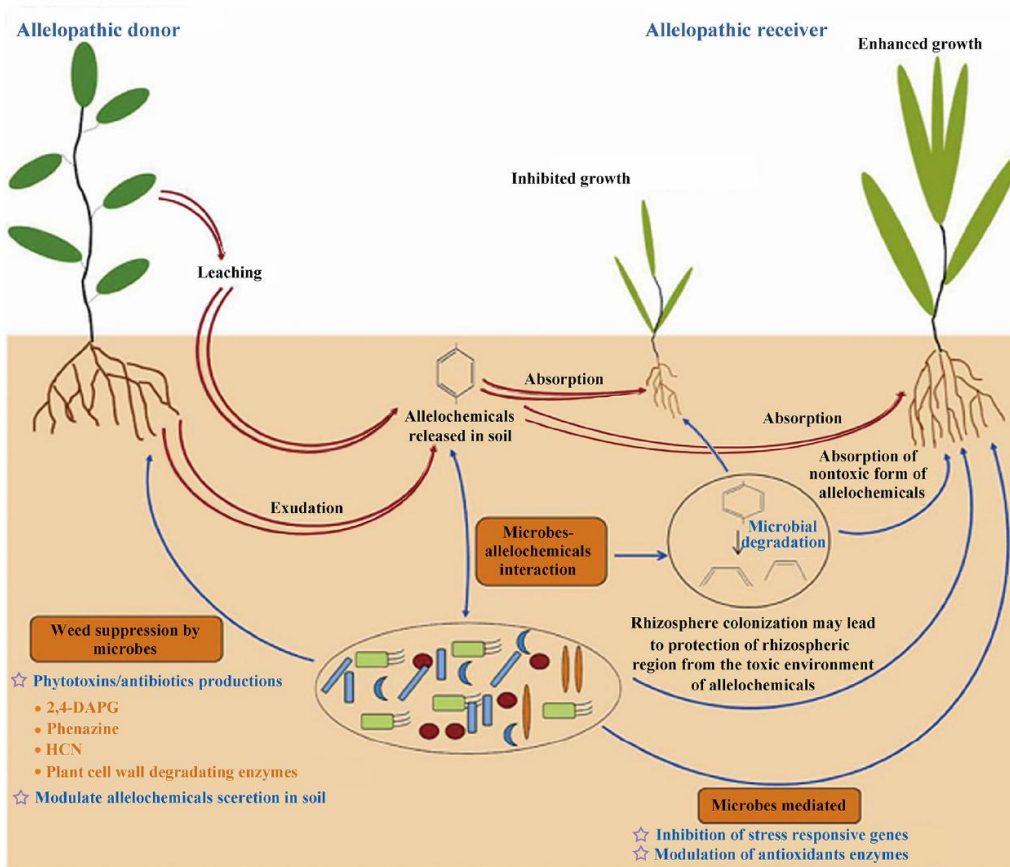
These chemicals may limit the growth of established plants or germination and growth of seeds and seedlings. Allelopathic interactions can be quite species-specific and can go both ways [21,22].



**Fig. 1. Zea mays growing in the presence of established weeds**



**Fig. 2. The 'weed triangle'. Figure credit: Ed Zaborsk; the University of Ilionis (adapted from Schonbeck and McCann, 2007 [19])**



**Fig. 3. Schematic representation of the mechanism of allelopathy in weeds**

At least 50 species of weeds have been shown to interfere with crops through allelopathic secondary compounds [23]. However, because allelopathy usually occurs through the complex chemical matrix of the soil, it is difficult to conclusively show a causal relationship. Some weeds, such as nutsedges, crabgrass, Canada thistle, and spotted knapweed are known to release allelochemicals toxic to many crops. On the other hand, some cultivated plants, especially cover crops like winter rye, mustards *Brassica spp.*, forage radish *Raphanus sativus*, and sorghum-sudangrass *Sorghum bicolor* X Sudanese can suppress many weeds through allelopathy [24,25,22].

## 2.4 Effects on Soil Microorganisms

Weeds and crops interact indirectly through their effects on soil microbial communities [18]. One plant species may harbour particular soil bacteria and fungi that either favour or hinder other plants to varying degrees. For example, the majority of

crops and some weeds form symbiotic associations with mycorrhizal fungi that greatly benefit the plant by enhancing nutrient and moisture uptake and protecting against soil-borne diseases. Certain plant families, including the brassica (mustard cabbage), amaranth (pigweed), buckwheat, chenopod (spinach, beet, lambs quarters), purslane, and sedge families, do not benefit from mycorrhizae (fungus-root symbiosis), but are instead somewhat weakened by the fungal infection [26,27]. Thus, a soil rich in mycorrhizal fungi may give grain, legume, allium, and solanaceous crops (all 'strong hosts' that benefit from mycorrhizae) a competitive edge over 'non-host' weeds like lambsquarters, pigweeds, smartweeds *Polygonum spp.*, buckwheat family, and nutsedges.

## 2.5 Weeds Interference in Pasture/Rangeland and Livestock

Undesirable plants in grazing land often reduce forage production by competing with native

plants and discouraging grazing near the plant, thereby directly affecting the land's usefulness for livestock grazing [28,29]. Leafy spurge is an aggressive perennial weed that readily competes with desirable vegetation in pasture and rangelands [30] and decreases herbage production by as much as 75% [31]. The plant is toxic to livestock [32] and poses a serious threat to livestock production on open rangelands. Cattle and horses avoid grazing lands of leafy spurge because of chemical irritants in the plant [33,31]. Poison hemlock (*Conium maculatum*) is found throughout the United States in pastures and crops and is considered very toxic. *Parthenium hysterophorus* is an annual herbaceous plant native to the tropical Americas, which is widely adventitious and now occurs in East Africa, parts of Asia and Australia [34]. The weed contributed to yield loss in Ethiopia, in a weed crop interaction between *Parthenium hysterophorus* and sorghum, [35]. Consequently, forage crops at harvest or when directly grazed could contain toxic amounts of poison hemlock [36]. Although livestock seldom eats hemlock because of its strong odour, they will ingest it if no other forage is available or if it ends up as a contaminant in hay or silage. Poisoning have been described in many species, including cattle [37], sheep [38], horses [39], pigs [40], goats [41] and poultry [42]. Poisonous weeds can be grouped according to the nature of the chemicals accumulated in them as nitrate accumulating weeds and Pyrrolizidine alkaloid accumulating weeds.

### 2.5.1 Nitrate accumulating weeds

There are several common crop and pasture plants, and weeds that can accumulate toxic nitrate concentrations [36]. Among weeds, pigweed (*Amaranthus spp.*), nightshades (*Solanum spp.*), and lambsquarters (*Chenopodium spp.*) have been found to contain nitrate at a potentially toxic concentration. Among crop plants, especially oat hay and sorghum have been incriminated with nitrate toxicosis. Alfalfa hay may be contaminated with pigweed or lambs quarters, thus presenting a potential source for nitrate poisoning [43]. Nitrate accumulates in the vegetative tissue, particularly in stems with lesser in the leaves. Seeds generally do not contain toxic nitrate levels. Heavy fertilisation of pasture, herbicides treatment, drought, cloudy weather, and decreased temperature may increase the nitrate concentrations in the plant. Nitrate poisoning is primarily a problem in ruminants because of the

reduction of nitrate to nitrite by ruminant microorganisms. Cattle are especially susceptible to nitrate toxicosis. The nitrite ion produces methemoglobin, which cannot react with oxygen, so anoxia occurs [44]. Methemoglobin leads to dark brown or chocolate-coloured blood, a common feature of nitrate/nitrite poisoning. Clinical signs of acute nitrate poisoning include depression, dyspnea, tremors, ataxia, rapid heartbeat, and terminal convulsions. Death may occur within 6-24 hours of ingestion.

### 2.5.2 Pyrrolizidine alkaloid accumulating weeds

Pyrrolizidine alkaloid (PA) poisoning is of great economic importance as a cause of progressive liver disease in livestock animals [36]. The disease has been reported from most areas of North America and is mostly caused by plants from the genus *Senecio*, but other plant genera such as *Amsinckia* and *Cynoglossum spp.* also, contain the toxic alkaloids. Horses and cattle are the major livestock species poisoned by PAs. Sheep, goats and small herbivores (e.g., rabbits, guinea pigs, hamsters) are resistant to PA toxicity due to detoxification processes in the liver [45]. Chemical signs of chronic PA poisoning may often not appear for 2-8 months after the first ingestion of PA containing icterus. Cattle may also develop photosensitisation. Neurological signs are commonly seen in horses, and the condition is called 'walking disease'.

## 2.6 Weeds Interference in Water Management

Terrestrial criteria for assessing weed competition cannot be employed in aquatic environments. There are no known appraisals of direct crop losses due to aquatic weeds. However, [46] reported nearly five decades ago, that manmade lakes above dams across major rivers in Africa, Asia and Central and South America became so badly infested with weeds within 5 to 10 years of construction that their usefulness for power development, boat transport, and irrigation was greatly reduced, and, therefore, one must conclude that national development was impeded by weeds. Aquatic weeds quickly reduced the designed flow of some irrigation canals in India by 40% to 50% and in others up to 80% [47]. Submerged floating weeds only retard it to 20 times [48]. Decreased flow reduces the possibility of irrigating distant fields and accelerated opportunities for leakage

and evaporation. In addition to agricultural concerns, those who use water for recreation or enjoy the aesthetic appeal of aquatic habitats are often disturbed by weeds. Aquatic weeds are often ugly, and their rotten remains are smelly, but the more important problem is that their presence and inevitable decay hastens eutrophication. There is more public concern about weeds in recreational waters than in agricultural waterways.

### 3. INVASIVE WEEDS

#### 3.1 Invasive Terrestrial Weeds and Their Threats

One of the single largest threats to our natural resources is the invasive species. Some weed species have been classified as noxious weeds by government authorities because if left unchecked they often compete with economic crop plants or cause harm to livestock [49]. They are often foreign species accidentally or imprudently imported into a region where there are few natural controls to limit their population and spread [50]. These foreign noxious weeds are also referred to as invasive weed species. Major weed invasions change the natural diversity and balance of ecological communities. These changes threaten the survival of many plants and animals because the weeds compete with plants for space, nutrients and sunlight. Several native and non-native plants are unwanted in a specific location for several reasons [51]. An important one is that they interfere with food and fibre production in agriculture, wherein they must be controlled to prevent lost or diminished crop yield. Other important reasons are that they interfere with other cosmetic, decorative, or recreational goals, such as in lawns, landscape architecture, playing fields, and golf courses.

Siam weed *Chromolaena odorata* is a perennial weedy shrub native to the Americas from Southern Florida to Northern Argentina including the Caribbean Island [52]. Following its introduction from Sri Lanka into Southern Nigeria in 1937 [53], it has reached alarming proportions in Nigeria [54,55], Cameroon, Ghana, and other parts of Africa [56], and is now one of the worst weeds in Nigeria and West Africa.

#### 3.2 Invasive Aquatic Weeds and Their Threats

Aquatic plants, like most water organisms, are more widely distributed throughout the world than

terrestrial plants. This is because factors or conditions required by aquatic plants are uniform in general than those to which land plants must adapt to [57]. The aesthetically pleasing appearance and unique growth of floating aquatic weeds have been responsible for their spread to various tropical and subtropical countries by a human during the 1800s and 1900s. In Kenya, aquatic weeds were used to grace aquaria and ornamental ponds from where they escaped into natural or artificial water bodies causing serious problems [58].

Invasive aquatic plants affect aesthetics, drainage for agriculture and forestry, commercial and sport fishing, drinking water quality, fish and wildlife habitat, flood control, habitats for other plants, humans and animal health, hydropower generation, or irrigation, recreational boating, swimming, water conservation and transport, and, ultimately, land values [59]. Some invasive aquatic weeds include water hyacinth *Eichhornia crassipes* and *Pontederiaceae*. These weeds block water pumps, reduce fishing activities and lead to an increase in water-borne diseases such as schistosomiasis in lake Victoria, [57].

### 4. BENEFICIAL PROPERTIES OF WEEDS

#### 4.1 Benefits of Weeds to Companion Plants

A common companion plant benefits from many weeds to attract and provide habitat for beneficial insects or other organisms which benefit plants. For example, wild umbellifers attract predatory wasps and flies. The adults eat nectar, but they feed common garden pests to their offspring [60]. Some weeds attract ladybirds, or the 'good' types of nematode, or provide ground cover for predatory beetles, which are generally thought as beneficial because they eat huge quantities of aphids, mites and other arthropods that feed on various plants. Many plants can grow intercropped in the same space, because they exist on different levels in the same area, providing ground cover or working as a trellis for each other [60]. This healthier style of horticulture is called forest gardening. Larger plants provide a windbreak or shelter from noonday sun to more delicate plants.

Many weeds protect nearby plants from insect pests from their allelopathy. Many scientists have highlighted the significance of *Euphorbia* species against insects, viruses, fungus and nematodes. [61] reported an effective reduction in the

hatching of larvae of cyst nematodes (*Heterodera avenae* and *H. cajani*) with *Euphorbia hirta*. Some beneficial weeds repel insects and other pests through their smell [6], for example, alliums and wormwood. Some weeds mask a companion plant's scent, or the pheromones of pest insects, as with ground ivy, as well as oregano and other mints. Some also are unpleasant, because of their spines or other features keeping them away from an area to be protected.

Weeds can also prevent pest insects from finding a crop because their presence disrupts the incidence of positive cues which pests use to locate their food. Recent studies on host-plant finding have shown that flying pests are far less successful if their hoist-plants are surrounded by any other plant or even 'decoy-plants' made of green plastic, cardboard, or any other green material. One scientific study said that simply having clover growing nearby cuts the odds of cabbage root flies hitting the right plant from 36% to 7% [6].

#### 4.2 Ethnomedical and Ethnopharmaceutical Uses of Weeds

There is increasing evidence to support the hypothesis that weeds are relatively high in bioactive secondary compounds and are thus likely to hold promise for drug discovery. Studies have proven the medicinal potency of some weeds in different areas. Additionally, the use of weeds as medicinal plants has also been discussed in the scientific literature, for instance regarding home garden weeds in South Africa [62,63] and rice weeds in Chhattisgarh, Eastern India [63]. [64] carried out ethnobotanical exploration to find out the medicinal values of common weeds present in crop fields and different places like crop rice, vegetables and other localities of Koraput, India. In their study, a total of 33 plant species belonging to 32 genera and 20 families were identified as being used for the treatment of approximately 36 ailments or therapeutic indications including headache, toothache and eye inflammation. While many people think of dandelion as annoying weeds, dandelions are a rich source of vitamins A, B complex, C, and D as well as minerals such as iron, potassium and zinc. The edible herbs have been used to help stimulate digestion, cure warts and reduce symptoms associated with the common cold and PMS [9].

Natural products can be important sources for new pharmaceuticals. Weeds are an important

source of medicines for indigenous people and have been in use by native people where they serve as good medicinal plants [65]. Analysis of 101 plant species from which 119 contemporary pharmaceuticals are derived shows that at least 36 of these plants are considered weeds [66].

#### 4.3 Ethnobotanical Uses of Wild Edible Weeds

There has been renewed or increasing interest in consuming wild food plants. Despite agricultural societies primary reliance on crop plants, the tradition of eating wild plants has not completely disappeared, their nutritional role and health benefits being reported in many surveys worldwide [67]. Several weeds, such as the dandelion *Taraxacum* and lambs quarter, are edible, and their leaves or roots may be useful for food or herbal medicine. Burdock is common over much of the world and is sometimes used to make soup and medicine in East Asia [68] show that weedy vegetables are an important resource for rice farmers in Kalasin, Northeast Thailand, not only as food but also because of the multiple additional users they have. The overlapping roles of wild plants as food and medicine have been discussed by various authors [10], and have been reported in different regions in the world such as Palestine [69], China [70], and Thailand [71]. In Spain, as in other Mediterranean countries, wild edible plants have played an important role in complementing and balancing diet based on agricultural foods, especially during times of shortage [72]. In the Mediterranean area, wild edible plants are important as dietary supplements, providing trace elements, vitamins and minerals. However, consumption is determined less by calorie input and more by the pleasure of gathering wild resources, recreating practices and enjoying characteristic flavours [67].

Both food and medicinal plants have interventional uses. This exists mainly in indigenous and local traditions. Food can be used as medicine and vice versa. However, certain wild edible plants are used because of their assumed health benefits and thus can be called medicinal foods.

#### 4.4 Uses of Weeds as Livestock Feed

Most weeds are palatable and of acceptable quality for animal feed if they are grazed or cut when young. Wild oat patches are particularly good green forage, while other grassy weeds,

such as quack grass, are also of high quality, generally similar to tame grasses. Weedy cereal crops can be cut when green, providing good livestock feed and reducing weed seed return in those areas ([www.producer.com/2005/03/weeds-ca-be-valuable-](http://www.producer.com/2005/03/weeds-ca-be-valuable-)).

## 5. CONCLUSIONS

Weeds are problematic to both agricultural and non-agricultural land uses in various ways. They are responsible for significant losses in crop yields and financial losses in agricultural production. Weeds, through competition with other plants, would almost always have deleterious effects on them. Weed invasion is the most threatening impact of weeds on agriculture, and causes a nuisance to human environments, disrupts the natural diversity and balance of ecological communities. Albeit weeds have many deleterious effects in nature, they still have many beneficial properties. Weeds, among the myriads of their beneficial properties, can be important sources for new pharmaceuticals and medicine for indigenous people and can have both nutritional role and health benefits. Given myriads of the deleterious effects and the benefits accompanying weeds, it is hereby suggested that more researches should be carried out on weed control and weed management, and more explorations on the potential uses of weeds to man, his environments and livestock are needed.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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