Chapter

Invasive Species in the Amazon

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Abstract

One of the main reasons for environmental disturbances such as declination in pasture productivity and biodiversity losses is the high infestation of herbaceous weeds, generally referred to as "Juquira" in the Amazon region. If they are not adequately controlled, such infestation might lead to degradation of pasture, resulting in complete loss of productivity and subsequent abandonment of the area. In this sense, this chapter aims to describe the main invasive species present in the Amazon region, as well as to characterize both the old and innovative techniques of use in agriculture, in large and small scale, for the control of agricultural pests.

Keywords: Juquira, weed control, Amazon region, agriculture, infestation

1. Introduction

In the last years, large areas of forest in the Brazilian Amazon have been deforested for agricultural activities. Due to some changes in environmental conditions in these areas, some native plant species, which were originally restricted to the edges of forests or clearings, increased in abundance. As a consequence, these species ecological and agronomic importance has changed significantly. For example, many have become important weeds in active farming or have thrived in abandoned areas [1]. In view of this, vegetative invasions are among the main causes of biodiversity loss. In this context, environments subject to anthropic disturbances, such as the Amazon region, are considered more prone to propagation and invasion of species that cause degradation and biological variety loss [2–4].

Weeds interfere with agricultural crops by reducing mainly the yield. This interference occurs due to the competition for water, light, nutrients, and chemical inhibition, affecting the germination and development of cultivated plants. Indirectly, weed species can cause damage to crops by harboring insect pests, fungi, and nematodes and make it difficult to harvest and also depreciate the harvested product quality [5].

According to Lorenzi [6], the weed conception is relative as no plant is exclusively harmful. On the other hand, cultivated plants correspond to those species sown or cultivated by man, while wild plants are all plant species that are born and reproduce spontaneously, which may interfere with crop production, domestic animals welfare, and the view aspect where they occur [6, 7]. Invasive plants are defined as any plants, either cultivated or wild, that vegetate in places where their presence is not desired [7].

Weeds have emerged from a dynamic process of evolution by adapting itself to environmental disturbances caused by nature or man through agriculture. This evolution continues until today in response to the agriculture modernization. Among the modern techniques used in agriculture, the herbicides used to control weeds have provided a fairly rapid evolution, making them in some situations resistant to these chemicals. The evolution of weed population resistant to herbicides is a growing problem in many countries. Thus, many research works are conducted, especially in the last 20 years, in order to study distribution, resistance mechanisms, genetics, and management of these populations [8].

According to da Silva et al. [9], in the cultivated pasture areas, the invasive plants correspond to the main maintenance cost factor. However, the relevance of their role in ecosystems and the available information on the biology and management of these plants is limited, with the majority of them being floristic or relating to the elaboration of control strategies, such as those mentioned in Dias Filho [1], Mascarenhas and Dutra [10], and Dutra et al. [11] work. Studies show that there are innumerable direct and indirect effects of invasive plants on man's agricultural activities, ranging from competition for essential mineral nutrients, light, water, and space, to alternative lodging of pests, nematodes, and parasitic plants [6, 12, 13].

In this sense, the objective of this work was to characterize some of the most commonly found invasive species in the Amazon, as well as to describe the main methods of these weed control.

2. Main invasive species in the Amazon region

2.1 Pau-de-lacre (*Vismia guianensis* (Aubl.) Choisy)

For invasive plants, successful invasion may be related to superiority in competition with native species. In this scenario, persistent perennial species are the ones that cause the most damages and live for several years and, in most cases, reproduce both by seeds (sexed) and vegetative (asexual) [14]. In this category, there are the most problematic species for agricultural pastures, such as lacre (*Vismia guianensis*) (**Figure 1**), which are inconvenient mainly for the extensive or semi-intensive production systems [15, 16]. *Vismia guianensis* is a plant, which belongs to the family Hypericaceae, order Malpighiales, and class Magnoliopsida, and it is distributed in North and Northeast Brazil [15, 16].

Vismia guianensis species, commonly known in the north of Brazil by the name of "pau-de-lacre," is a rough perennial plant with a brown coloration [18]. The leaves are greenish and shiny, and on the dorsal part (bottom), they are rough and ferruginous in color. When the leaves are removed, an orange colored viscous liquid flows from

Figure 1.
Species lacre (Vismia guianensis), adapted from [17].

the cut, and the inflorescences of this species present yellow flowers with globally green fruits, containing a large number of seeds. *V. guianensis* species is a bushy plant, distributed in the forest edge, being able to reach from 2 to 5 m height [19]. The flowering extends from November to March, extending until May; in some individuals, the peak of flowering occurs between December and January. The fruits conserve color even when mature, thus visually impossible to distinguish from the immature [14, 16, 17].

V. guianensis propagates aggressively from the stems and roots. This process, according to [19], is the main stimulus to growth after the cutting or burning of the species propagation areas. And one of the main problems arising from the *V. guianensis* dispersion is the competition for environmental factors (light, water, nutrients, and space) with native or cultivated plants in the environment [20]. This species also has high growth, proliferation, and dispersal capacity and is capable of modifying the composition, structure, or ecosystem function.

2.2 Capim-navalha (*Paspalum virgatum* L. (Gramineae))

Another invasive species frequently found in agricultural production pastures is the *Paspalum virgatum*, commonly known as "capim-navalha" (**Figure 2**). It is an invading pasture grass, recognized as a weed in the Amazon. Its propagation leads to diseases that cause progressive death of susceptible grasses, opening space for the colonization of weeds and leading to pasture degradation [15]. *Paspalum virgatum* is a plant species, which belongs to the family Poaceae, order Gramineae, Monocotyledons class, with hypogynic stamens. It is a perennial, herbaceous, erect weed, with a size of up to 1.50 m height, has a great protein value, but when adult, it becomes fibrous and not palatable to animals. Its flowering occurs between the months of October and May, season of greater intensity of rains, especially in Amazonian regions. Plants of this species usually inhabit humid environments, borders of streams, rivers and are also frequently found in pastures [15].

Capim-navalha (*P. virgatum*) is a Central America and South America native species [21]. In Brazil, it is found in all states of the North, especially in humid areas with high multiplication capacity. Capim-navalha also receives other denominations, such as navalhão, capim-duro, capim-cabeçudo, capim-taripucu, and capim-capivara [15]. *P. virgatum* is a cespitosa and rhizomatous grass, with clumps reaching 1.5 m in height, fibrous roots and upright leaves with 50 to 75 cm long and 1 to 2 cm width [22].

Figure 2.
Capim-navalha (Paspalum virgatum), adapted from [15].

The problems caused by their high multiplication capacity compete with fodder (common name given to feeding or lining the place where the animal sleeps), especially in moist soils where cattle graze only young plants of capim-navalha, while the equines appreciate the seeds and help to spread the infestation in the pasture. It also interferes negatively on plant growth through competition for water, nutrients, and allelopathy, with influence on pasture establishment and pasture regrowth ability after grazing and control difficulty by conventional methods [9, 15].

2.3 Malícia (*Mimosa pudica* L.)

Mimosa pudica L (**Figure 3**) is an invasive plant species, belonging to the genus *Mimosa*, subfamily Mimosoideae, family Fabaceae or Leguminosae and order Fabales [23]. *M. pudica* L. is a semi-prostrate herb, also very found in the Amazon, prickly or underbush up to 0.5 m height [24], of branched stems, with numerous bristly and deflected hairs [25]. The leaves are very sensitive, folding when touched

Figure 3.
Malícia (Mimosa pudica L.)

and digitally dividing with one or two pairs of sessile, alternates, petiolate, stipulated and linear lanceolate hairs [24, 25]; the flowers on the globular head are pink with prickly peduncles, while the fruits are indehiscent, simple, dry, with 1–1.6 cm in length and 0.4–0.5 cm in width, housing two to five seeds [24].

M. pudica is known with several colloquial names. The most recurrent are: malícia [26], planta tímida, planta sensível, and planta humilde [24, 27, 28]. This invasive plant species belongs to the Fabaceae family [29, 30], showing the following variations: *Mimosa pudica* var. hispida Brenan, *Mimosa pudica* var. tetrandra (Humb. & Bonpl. ex Willd.) DC., and *Mimosa pudica var. unijuga* (Walp. & Duchass.) Griseb [29].

This species is native to Africa and Asia, but it is common to be found in North and South America and with excellent adaptation in Brazil, especially in the Amazon region [29, 31]. According to Azmi et al. [25], perhaps it is native to many or all the tropics of the New World, and today its distribution may be pantropical.

It grows more in well drained soils, but also grows in scalded or eroded soils, soils with low concentrations of nutrients, at sea level or at altitude up to 1300 m, intolerant to shade, not competing with large vegetation, or growing under the canopy of trees [25]. This species is an invasive plant of pastures, agricultural areas, orchards, roadsides and roads, cut areas, areas disturbed by construction, polluted areas, among other productive areas of commercial and/or open fields [24, 25, 30].

The adaptation and proliferation of this weed is due to factors such as large seed production and anti-herbivore defenses (this occurs with the leaves rapid movement and the petiole decline) [25, 32–34]. These leaves are also in response to stressors such as electrostimulation, wound, wind, vibration, touch, drought, change of lighting, and warm or cold stimuli, which help the plant to protect itself or adapt to a particular environment condition where the vegetable is inserted [25, 27], such as at light levels [25, 27, 28]. In addition, in the plant radicle nodules occurs a symbiotic bacterial association that transforms the atmospheric nitrogen in a useful way for the plant, benefiting its development [30]. This species also has cylindrical roots with a slightly rough surface or wrinkled longitudinally, tapered, with secondary and tertiary ramifications, varying in length and thick up to 2 cm [24]. They are still capable of producing carbon disulfide, which selectively inhibits the rhizosphere colonization by mycorrhizal and pathogenic fungi [25]; and finally, the soils, which are often burned, allow the spread of this weed [27].

This plant produces the amino acid mimosine and its metabolite, 3-hydroxy-4-(1H)-pyridone (DHP) which, when ingested, is toxic to horses, cattle, pigs, and sheep, causing hair loss, low growth, oral ulcerations, and goiter not prevented by iodine supplementation [35].

2.4 Mata-pasto (*Senna obtusifolia* (L.) Irwin & Barneby)

Another important invasive species is the *Senna obtusifolia* (**Figure 4**). This is an invasive and erect stem plant without spines, measuring from 1.5 to 2.0 m in height, and the leaves are in pairs with three pairs of leaflets, hairless, and not brittle [36]. The name *Senna obtusifolia* comes from Latin *obtus* (opaque or blind) and *fólio* (leaf) [37]. This species of invasive plant is very common, infesting crops in tropical and subtropical regions of the world. It is an annual plant with woody base, belonging to the Fabaceae family, subfamily Caesalpinioideae, and order Fabales that reproduces itself by seeds, that are in the form of a cluster with yellow petals and sprout especially in spring and summer [38–40]. In the same way as other invasive species, *Senna obtusifolia* produces seeds on a large scale [41]. In the case of this species, this is due to the fruits with multiple seeds [38]. It also has an ultra-aggressive radicle system, giving it a high competitive capacity, even in periods when the soil has low

Figure 4.
Mata-pasto (Senna obtusifolia).

hydric availability [39], although it does not present nitrogen fixing nodules in the roots, which is common in many species of *Senna* and that is of extreme importance for invasive plants [41].

Researchers believe that *Senna obtusifolia* originates in the Caribbean and in tropical South America [40], but has spread widely and exhibits a global pantropical distribution [39, 40], as it can be found in Africa, India, Sri Lanka, Pakistan, Central America, Malaysia, Philippines, Indonesia, Papua New Guinea, South America, Caribbean, USA, and Australia [37, 40]. This species is present also in environments of 1600 m altitude, as in Mexico and Tanzania [40].

It is known by many different names in different parts of the world, but the most common are: mata-pasto [26, 36], sicklepod [39], fedegoso, and Feijão-Java [37, 40]. It is a very aggressive weed of agricultural areas of a wide variety of crops and in several countries, being predominant in plantations of soybean, peanuts, cotton, sugarcane, corn, disturbed areas, such as animal husbandry pastures, and open ecosystems [37–40, 42].

Weed competition and interference affect agricultural productivity, thereby significantly reducing the productivity of the planted crop, as well as altering the structure and function of the local natural ecosystem [40]. Another prejudice caused by *Senna obtusifolia* occurs when bovine animals consume the green leaves and fruits in pastures and/or feed contaminated with leaves, stems, and seeds of the plant, causing serious poisoning, which can lead the animal to death [36].

2.5 Tiririca (*Cyperus rotundus* L.)

Cyperus rotundus L. species (**Figure 5**), also known as tiririca or erva-cidreira, belongs to the Cyperaceae family. This is the third largest family of monocotyledonous plants [43]. It is a colonial herb, perennial, has 7–40 cm of height with fibrous roots, and reproduces largely by rhizomes and tubers. Rhizomes can grow in any direction on the ground, those growing up produce shoots and roots; the rhizomes that grow down horizontally form individual tubers or tuber chains. Mature individual tubers are reddish brown, about 12 mm thick and ranging between 10 and 35 mm in length. Tuberous roots act as the main dispersion units over time, remaining dormant in the soil for long periods. Tuber dormancy causes irregular emergence, contributing to the persistence of the propagules of this species [44].

Figure 5.
Tiririca (Cyperus rotundus).

The leaves are dark green, bright, narrow, and similar to herbs, ranging from 5 to 12 mm wide, and 50 cm long. The vertical stems support a branched inflorescence with bisexual flowers with three stamens, and a pistil with three stigmas. Nuts are rarely produced [44].

Cyperus rotundus is a weedy plant that is difficult to handle and causes damages in several commercial crops. Damage results from competition throughout the cycle, but the most critical periods are in the early stages of crop development and crop reforms. For it being a perennial species, and for its broad adaptability to many agricultural environments and the ability to reproduce sexually and asexually, *C. rotundus* is among the 20 most damaging species in the world [45].

On the other hand, *Cyperus rotundus* has its medicinal imprint. It is widespread in many tropical and subtropical regions of the world [46] and is considered to have originated in India for over 2000 years and is regarded as one of the best herbs for medicinal purposes. Studies indicate that the rhizomes of *C. rotundus* are used as traditional remedies for the treatment of stomach and intestinal disorders and inflammatory diseases in Asian countries [47–49]. Studies on the ethnobotanical use of *C. rotundus* showed that rhizomes were used to treat diseases of aging, apoptosis, atherosclerosis, cancer, cystitis, epilepsy, genotoxicity, hirsutism, nociception, and prostatitis [50]. It is reported that the tuberous part of *C. rotundus* is used for the treatment of dysmenorrhea and menstrual irregularities since antiquity [51].

2.6 Dente-de-leão (*Taraxacum officinale* L. Weber ex FH Wigg)

The species *Taraxacum officinale* (dente-de-leão) (**Figure 6**) is a perennial herb native of Europe, considered an aggressive invasive species worldwide [52]. In its

Figure 6.
Planta dente-de-leão (Taraxacum officinale), adapted from [23].

native distribution, *T. officinale* is present in alpine environments, mainly restricted to disturbed sites [53].

Widely distributed in the northern hemisphere, the *Taraxacum* genus is a member of the Asteraceae family, of Cichorioideae subfamily. *Taraxacum officinale* (dente-de-leão) is a perennial stemless weed, green leaves are grouped at the plant base, and the whole herb contains white latex. The flowering stems stand out with yellow flowers. Dente-de-leão plant is deeply ingrained, which means that the plant is also capable of producing a new plant even after its aerial part has been clearly cut. The herb is harvested between spring and autumn when the plant begins to bloom. Whole herbs are cleaned and dried in the sun until their moisture content is less than 13.0% [54].

Taraxacum officinale shows high tolerance to abiotic stress and efficient use of resources due to high plasticity in morphological and physiological characteristics [55–57]. Thus, when it presents favorable abiotic conditions, *T. officinale* shows greater abundance, physiological performance, accumulation of biomass, survival, and seed production [58, 59].

Taraxacum officinale has already been recognized as a useful passive bioindicator for heavy metals in urban areas [60], as well as a potential indicator for several trace elements, but only in highly polluted industrial areas. In response to vestigial elements, this species exhibits some micromorphological alterations. However, the lack of visual effects and the occurrence in industrial areas of medium pollution with reduction of heavy metals content in soils may indicate their potential for bioindication and phytoextraction [61]. It has all the necessary resources for good bioindicators: it is widely spread geographically, characterized by relatively high tolerance to environmental pollutants, and shows a correlation between the pollution level of a certain environment element (air and soil) and these substances concentration (metals heavy, polycyclic aromatic hydrocarbons) in plant tissues [62, 63].

3. Traditional methods of weed control

The invasive plants control has great relevance in agriculture, since these species bring losses to native species, communities, and ecosystems with the loss of their nutrients, decrease in yield, and quality of the crop, bringing direct impacts to human life and other species. Several techniques can be used to reverse, interrupt, or decelerate infested areas making them healthy again.

There are methods used to reduce the development and performance of invasive plants. The three most viewed are: (a) prevention, which involves preventive measures to introduce these plants into an ecosystem, (b) eradication, which contemplates the extermination, including its seeds however studies show that it is practically impossible to be carried out in large areas and it is economically unviable, and (c) control, that according to Tu et al. [64], some of the more traditional control options are manual, mechanical, competition between native plants, grazing, herbicides, prescribed fire, solarization, and flooding involving chemical, physical, and biological methods [65, 66].

3.1 Chemical methods

The chemical control main advantages are: (a) efficiency; avoids the competition of weeds since the crop implantation; (b) allows controlling weeds in rainy season, when mechanical control is impracticable; (c) does not cause damage to the crop roots; (d) does not revolve the soil; (e) allows better distribution of the economic crop plants in the area; (f) controls weeds in the main crop line; (g) and is of rapid operation. While important for reducing costs and increasing productivity, its indiscriminate use is a global environmental problem as it affects living organisms. Among the disadvantages are the cost, generally higher than the other methods; requires adequate equipment; may be toxic to man and animals; contaminates the environment and can leave residues in soil and food [67, 68]. The intensive use of phenoxyalkanoic acid herbicides in agriculture has an adverse effect on the environment that involves water pollution, among other phenomena. In many countries, phenoxyalkanoic acid herbicides have been found in groundwater, surface, and potable water in concentrations that have exceeded the maximum permissible limits, which determines an environmental problem [69].

Chemical control is important mainly in places where there is high weed infestation and low availability of water and nutrients, and the time available for control is reduced due to the area size or the lack of high-performance equipment. In large soybean plantations, chemical control is the most commonly used method due to agility and efficiency. Farmers using the chemical method should be aware of the interactions between the variety being used and the herbicide to be applied, as some cultivars are more sensitive than others to certain herbicides [68].

It is possible to halve the amount of herbicides without loss in weed control effectiveness and crop yield by combining chemical weed control in line with cross-line collection [70].

3.2 Physical methods

The physical control begins with several aspects that range from the use of a suitable crop to the chosen place, study of planting season, and adequate seeds, to the study of characteristics such as configurations, density, soil, and climate. Another physical control occurs with the grinding and pre-incorporation of fertilizers and remaining plants with subsequent plowing in moist soil, as this can considerably reduce the growth of invasive plants. Still evaluating the physical methods, there is a third alternative that is the use of crop rotation, which reduces the incidence not only of invasive plants but also of pests and diseases. And, as a last indication, the mechanic, who uses from hoes, passing through tractors, or even animal traction. This method was widely used for its low cost, and the need of not very modern equipment, so that its range is still great among rural producers and families to contain invasive plants and adequate development of their planting [71].

3.3 Biological methods

Biological methods are most appreciated in weed control against chemical and physical methods due to the viability of use in any situation. According to Weed Science Society of America [72], the biological control of weeds is defined as "the use of an agent, a complex of agents, or biological processes to bring about weed suppression"; some examples of agents used are arthropods (insects and mites), plant pathogens (fungi, bacteria, viruses, and nematodes), fish, birds, and other animals. Some advantages in using biological methods compared to other methods are related to the decreased risk of soil, water, and food contamination by herbicide residues, bringing healthier and sustainable cropping systems, besides being low cost and self-sufficient [73].

4. Recent methods of weed control

4.1 Use of agrochemicals

The predominant agriculture in the world, in addition to high productivity, is also characterized by its dependence on fossil energy sources, such as fertilizers and pesticides. However, the increasing increase in the use of agrochemicals as it has been happening may not be sustainable over time, not only because these products pollute the environment and promote the intoxication of animals and humans but also because new breeds of insects and new species of invasive plants, both resistant to insecticides are appearing with increasing frequency [74].

The number of cases of resistance to insecticides and fungicides increased rapidly after the 1950s and 1960s [75]. Since the first report by Ryan [76], which observed resistant *Senecio vulgaris* biotypes to the herbicides belonging to the chemical group of the triazines, it have been observed an increasing number of weed species with biotypes resistant not only to triazines but also to other classes of herbicides.

Weed resistance to herbicides may result from biochemical, physiological, morphological, or phenological changes of certain weed biotypes. Many cases of resistance to herbicides result from either altering the herbicide site of action or increasing its metabolism, or the departmentalization and compartmentalization of the herbicide in the plant. Although these general mechanisms are similar to some crop selectivity mechanisms, which allow them to survive herbicide exposure, specific herbicide resistance mechanisms in weeds typically differ substantially from those responsible for crop selectivity [77].

Some natural chemicals are used as a model for obtaining new herbicides. In addition, chemicals with proven allelopathic activity can be concentrated and have their allelopathic effect potentiated in the laboratory [78].

4.2 Alternatives in agricultural pest control

Over the past seven decades, considerable efforts have been expended to detect plant species with potential for use in a variety of human activities, such as medicine, cosmetics, hygiene, and food industry. Obviously, popular knowledge and medicinal use of many plant species, especially by indigenous communities, for example, played a prominent role at the beginning of the research, allowing studies based on a minimum of available information, which reduced research time and speed advances [79].

Theoretically, all plants are capable of producing chemically highly diversified compounds, some of which have potential for use in weed management. This specificity can be detected in both native and cultivated plants, although in the first—even because they have not been domesticated—such properties may be more auspicious. Identifying and selecting, depending on the degree of toxicity, plants species with potential for such purposes have become a primary activity in many universities' laboratories and research institutes around the world. Good examples are found in the Souza Filho et al. and Iqbal et al. work [80, 81].

Studies in the literature have shown that certain plants in nature have the ability to synthesize compounds that can act in the development and growth of other organisms in the same ecosystem [82]. For Miller [83], the study of the allelochemicals is fundamental, because the action of such substances is of extreme importance for the understanding of the organism interactions in both natural and agricultural ecosystems.

In addition to these aspects, the perception that these plants may provide new prospects for agricultural exploitation adds to the innumerable possibilities of using biodiversity, not only for microorganisms but also for plant species [79].

4.3 Allelopathy: a natural method for weed control

Müller [84] proposed the term interference to classify the different types of change that develop among the various components of a plant community. This term was subdivided by Szczepahiski [85] in three groups: allelospoly, allelopathy, and allelomediation. Allelospoly or competition was defined as interference caused by the different components of the ecosystem by removing from the environment elements such as water, nutrients, and light, lowering it to levels that hinder normal development of others. Allelopathy is the alteration caused by the release of a chemical substance, elaborated by one or more components that affect certain elements of the community, and allelomediation or indirect interference is defined as the effects that alter the physical or biological environment, with reflexes in the living beings.

Allelopathy is a phenomenon that occurs largely in nature and has been postulated as one of the mechanisms by which some plants may interfere with others in their neighborhoods, changing the pattern and density of vegetation in a plant community [82].

From an agronomic point of view, allelopathy is of great interest as it allows not only the selection of pasture plants that can exert a certain level of control of some undesirable species such as invasive plants but also the establishment of grass species and forage legumes that are not strongly allelopathic among them and that can thus compose more balanced pastures, with favorable effects on productivity and longevity [86].

The most frequent studies on allelopathy are related to the effects of plant extracts on the germination and growth of others. In general, germination is less sensitive to allelochemicals than seedling growth [87].

Allelopathy may play an important ecological role in the near future as a source of new chemical substances with possibilities of use in Brazilian agriculture, similar to what already occurs in other countries such as Japan, Germany, and the United States, as a pasture management tool, and/or as supplier of basic structures for agricultural biodefensive production [74].

Chemicals that impose allelopathic influence are called allelochemicals. Allelochemicals have a very diverse chemical nature ranging from simple hydrocarbons to complex polycyclic compounds with high molecular weight. Such compounds are in general short chain fatty acids, essential oils, diterpenes, alkaloids, steroids, phenolic compounds: flavonoids, naphthoquinones, anthraquinones, and coumarin derivatives [88].

Numerous chemical substances with allelopathic potential are described in the literature, but some chemical classes deserve greater attention [89]. The saponins may be formed by glycosylated triterpenoids with a hydrophilic polysaccharide chain or by hydrophobic steroids, which give them the detergent property and, consequently, the ability to bind to cell membranes, affecting cellular functioning. They are known for their hemolytic properties and toxicity to molluscs, insects, and fungi [90].

Flavonoids are present in plants in various forms and with varied functions. They include flavonoids, flavones, flavanones, catechins, anthocyanins, proanthocyanidins, and isoflavonoids, among others. In addition to the pigment functions, attractive or repellent of herbivores, protection against UV radiation, these substances have allelopathic effects, being able to inhibit the growth of plants and fungi [82, 91, 92].

Finally, the alkaloids encompass more than 12,000 structures already described, behind only the terpenoids. Approximately 20% of plant species accumulate alkaloids, molecules characterized by low molecular weight, and origin from phenylalanine, tyrosine, tryptophan, and lysine [88, 93, 94]. According to Rice [82], several alkaloids are able to inhibit the growth of bacteria, in addition to being toxic to some invertebrates.

Most studies report that allelopathic compounds act as inhibitors of germination and growth [95]. However, some studies have demonstrated that these compounds can also act as growth promoters [96, 97]. Apparently, most if not all organic compounds that are inhibitory in some concentrations are stimulants in lower concentrations [82, 88].

Invasive species	Control methods			Site
	Biological	**Chemical**	**Physical**	
Hypericum perforatum	Herbivorous insects (classic)	—	—	Southern and Western parts of Australia
Cryptostegia grandiflora	Rust of *Maravalia cryptostegiae* (modern)	Herbicides (modern)	—	Tropical Queensland, Australia
Spartina alterniflora	—	Herbicides (modern)	Cutting and crushing (classic)	Willapa Bay
Euphorbia esula	*Spurgia capitigena* (modern)	—	—	North America
Cirsium arvense	*Aceria anthocoptes* (modern)	—	—	United States of America
Schinus terebinthifoliu	*Crasimorpha infuscata* Hodges	—	—	Hawaii—United States of America
Acacia dealbata	—	Herbicides (modern)	Cutting and pruning	Northwest Spain
Pteridium aquilinum	—	Herbicides (modern)	Firing, manual and/ or mechanical removal	Northern California
Bromus tectorum	—	—	Cutting and defoliation	Eastern Oregon (United States of America)
Centaurea maculosa	Biocontrol (modern)	—	Firing	North America, Western United States of America
Chondrilla juncea	*Aceria chondrillae* (modern)	—	—	Canada

Table 1.
Weed control methods in different parts of the world [101–109].

Many of these studies approach, under laboratory conditions, the effects of aqueous or even hydroalcoholic crude extracts on seed germination and elongation of the radicle and hypocotyl of different weed species [96, 98, 99].

It is known that under field conditions, there is no way to separate the effects attributed to competition from those of allelopathy, since the influence of plants on other species in their neighborhood is a complex combination of competition interference and allelopathic chemical reactions [100].

Table 1 shows the main weed control methods that are applied in the world.

5. Conclusion

The weeds are the main bioeconomic factor to impose limitations to the agricultural activities' performance developed in the tropical regions, such as Amazon, especially in the quality and productivity of the pastures offered to grazing animals, which are severely affected by these types of plants. Therefore, its adequate control is of fundamental importance for the most varied aspects, such as profitability, agronomic performance, and activities longevity. Another important aspect is the herbicides indiscriminate use reduction, which, as a consequence reduces the environmental and human health damages. Finally, the search for alternatives to the herbicides on the market, such as the numerous metabolites produced by plants, can provide surprising diversity of chemical structures, which offer excellent prospects for increasing the search for more specific types of herbicides and less damaging than those in use.

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