Journal of Agriculture and Ecology Research International
5(1): 1-8, 2016; Article no.JAERI.16391
ISSN: 2394-1073

SCIENCEDOMAIN *international*
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The Spread, Impact and Control of *Chromolaena odorata* (L.) R.M. King and H. Robinson in Grassland Area

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JAERI/2016/16391
Editor(s):
(1) Ahmed Esmat Abdel Moneim, Department of Zoology, Helwan University, Egypt And Institute of Biomedical Research Center, University of Granada, Spain.
Reviewers:
(1) Anonymous, Universidade do Estado do Rio de Janeiro, Brazil.
(2) Anonymous, University of Sciences and Technology Houari Boumediene, Algeria.
Complete Peer review History: http://sciencedomain.org/review-history/11308

Review Article

Received 30th January 2015
Accepted 21st May 2015
Published 7th September 2015

ABSTRACT

Chromolaena odorata is native to tropical America and has been reported as one of the world's most invasive species in the humid tropics and subtropics. As an attempt to generate information useful for preventing and controlling the weed in grassland area, the spreads, impacts and controls of the weed are reviewed. Some attributes that contribute to its success as invader weed were described. Its impacts, both negative and positive on grassland ecosystem were presented. Possible solutions to prevent the spread of the weed and its control in grassland area were also discussed.

Keywords: Chromolaena odorata; dispersal; impact; control; grassland.

1. INTRODUCTION

A major constraint to livestock production in many tropical and developing countries is the scarcity and fluctuating quantity and quality of year around forage supply. During the rainy season, tropical forage species grow at very fast rates, with forage yield often exceeding animal's

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requirements. If not grazed or fed by animals, such forage becomes fibrous and lack of most essential nutrients which required for improved microbial fermentation and performance of animals. Conversely, during the dry season, pasture plant growth becomes slower or stop and the effect of inadequate feeding on livestock productivity may be serious.

Since the last four decades, forage supply from grassland area in many tropical countries has been continuously decreasing, mainly due to conversion of grassland to crop cultivation and invasion of noxious exotic plants. Invasion of world's grassland by shrub plants is among the dominant changes in the earth's vegetation during the last two centuries [1]. In Indonesia, invasion the exotic invasive plant *Chromolaena odorata* (Fig. 1) has transformed grassland ecosystems into worse conditions. Its fast growing and highly competitive ability traits making this weed lowering productivity and reducing grassland area for livestock. In the pasture area owned by Faculty of Animal Science Hasanuddin University in Enrekang regency, Indonesia, the weed has covered more than 50% of grassland area. Lacks of forage because of reducing carrying capacity of invaded grassland generally occurs during the dry season and during the season, many cattle are dead because of starvation. Furthermore, this weed is avoided by livestock as its leaves have offensive odor and bitter tasting. If it is not controlled, the change from grassland to almost pure stand of Chromolaena as reported by [2] can happen rapidly. To avoid this possibility becomes real, understanding in depth about biology and ecology of this weed is needed. Many investigations relating to the spread, impact and control of the weed have been reported and it seems appropriate to review and discuss these findings to reduce invasiveness of the weed in grassland area.

2. SPREADS

Chromolaena odorata (L.) R.M. King and H. Robinson, commonly known as siam weed, devil weed, bunga semak putih (Indonesia) and several other names in different countries (hereafter is called Chromolaena), is native to tropical America and has become a major invasive weed of grasslands, plantation crops and forests in the Old World tropics; from west and south Africa to Southeast, South Asia and the Pacific region [3,4]. The initial spread of

Fig. 1. *Chromolaena odorata* plant

the weed in Asia took place in the early 1880's when it was introduced as ornamental plant to the Botanical Garden in Calcutta India, then propagated throughout South East Asia and parts of Oceania [5,6]. In Indonesia, it was introduced to Deli in the east coast of North Sumatera in the beginning of commercial cultivation of tobacco in the turn of twentieth century [7] and in eastern Indonesia, the weed was first sighted in 1970's [8]. Transmigration program, with the movement of people, vehicles and equipments from Java was responsible for the spread of the weed to eastern Indonesia [4]. The weed has been introduced either intentionally or unintentionally to a new area far from its native areas. It was intentionally introduced to Ivory Coast in 1952 to control *Imperata cylindrica* other coarse grasses growth [9], however the major causes of its spread is through unintentional seed contamination [4].

The weed can spread through both sexual and vegetative means but the main spread method is through sexual propagation. Sexual propagation starts when the weed forms flower at one year old and increased until the stand is ten years old [10]. Flowering is initiated by a decrease in both day length and rainfall and peaked in December-January in northern hemisphere and in June-July in southern hemisphere [11], and close to the equator, the flowering may lose synchrony and generally occurs at the start of dry season [4]. Flowering is often prolific, but fertile seed is produced without pollination, as the weed is apomictic [12]. Flowers are capable of producing huge quantities of seeds, with estimated from 93,000 [13] to 1,600,000 seeds per plant [14]. Seed viability varies; most seeds didn't viable for more than 1 year; the remaining 1.4% seedlings survived into the second year [9]. Seeds tend to degrade in high moisture and temperature environments [10]. The light, narrow seeds, topped with a turf are easily dispersed by wind over a short distance and can spread over a long distance by attaching to clothing, fur animals, machinery, etc. [4], but the primary long-distance vector responsible for its spread is human activity. During the World War II, contamination of the weed seeds with moved military equipment and personnel were the major source of long-distance spread in the Asia and Pacific regions [6].

Seeds which fall under dense vegetation may lie dormant until the land is disturbed by clearing, like burning, cultivation and overgrazing [4], because light is needed for germination and growth [15]. In grassland area, animals will avoid land invaded by the weed and subsequently tend to overgraze on non-invaded lands. If water is sufficient, overgrazing which leaves patches of bare soil may be sufficient to stimulate germination. Once it germinated and established, *Chromolaena* that has a high competitive ability and allelopathic trait making this weed posses the ability to suppress the growth of forage plants and other shrub.

Besides by seeds, cut branches of roots and stem of *Chromolaena* can form roots and shoot, and these may spread during cultivation and other soil moving activities. Stem cutting could produce adventitious roots from the internodes within eight days under field conditions [15]. Under moist conditions, branches trailing on the ground may form roots [11]. The underground organ also can aid its survival in case of fire, drought or mechanical damage through coppicing. But vegetative propagation does not contribute significantly to its spread [11].

3. IMPACTS

Once established, *Chromoleena* grows rapidly. It has extremely fast growth rate (up to 20 mm/day) and often forms a dense thicket of height 1,5 – 2.5 m in open areas that can grow through and over the existing vegetation. In grassland area, the weed exerted positive and negative impacts. Table 1 below listed some impacts of the weed on grassland ecosystem.

4. CONTROLS

Studies have been carried out all over the world to control the weed. The best form of invasive species management is prevention. Preventing the spread of the weed will reduce future problems. If prevention is no longer possible, it is best to treat the weed infestations when they are small to prevent them from establishing. Investigations have shown that the weed can be controlled mechanically, chemically, culturally or biologically Mechanical controls have been the predominant method to control the weed. Hand weeding such as slashing, uprooting and digging out of the young plant is the most common method used in many countries. The use of tractor drawn equipments are limited to accessible area. Slashing reduces the standing weed biomass but it is not a solution because the

Table 1. Impact of *Chromolaena* on grassland ecosystem

No.	Negative impacts	Authors
1.	It has allelopathic effects on growth of other plant species	[16]
2.	Dense thicket of the weed prevents the free movement of livestock	[11]
3.	Shades out the growing forage, reducing the growth of grasses and legumes and plant biodiversity, preventing establishment of other plant species, interfering natural ecosystem process and altering integrity of natural plant community.	[17]
4.	Reduced carrying capacity of grassland from approximately 6 ha/head of cattle to more than 15 ha/head (in South Africa).	[18]
5.	Reduced cattle population from 2000 to 800 heads at Magoga Sisal ranch, completely closed down of Nkhlashhane Sisal ranch in Swaziland	[2]
6.	Harms the economy of small holder farmers in Indonesia because of lack of forage for their livestock.	[19]
7.	Reduced the population of banteng (*Bos javanicus*) and deer (*Cervus timorensis*) as caused by severe reduction of herbage yield in East Java, Indonesia.	[20]
8.	Threatening the endangered black rhinoceros (*Diceros bicornis*) as resulted from reducing its natural feed supply (in Maputaland, Africa).	[21]
9.	Reduces ecotourism potential and game-farming areas as reduced game areas and visibility.	[21]
10.	Consumption of the weed flowers may cause pyrrolizidine toxicity that can destroy the liver of cattle and goat.	[22]
11.	Consumption of the weed leaves may cause nitrate poisoning in animals.	[23]
12	Invaded grassland can be a harbor introduced wild pigs, rodents and insects	[24]
13.	The weed harbors of grasshopper, *Zonocerus variegates* that breeds in the weed and from there, moves to cassava, feeding on the leaves and causing yield losses.	[25]
14.	Reduced water run-off in water catchment as the greater biomass and higher rates of transpiration of *Chromolaena* compared to indigenous vegetation	[21]
No.	**Positive impacts**	
1.	Soil under *Chromolaena* had higher minerals and better physical soil properties.	[26]
2.	Increased organic carbon (27.9%), total nitrogen (36.7%), total phosphorus (56.8%), extractable calcium (68.3%) and magnesium (140.3%) relative to savannah soils.	[27]
3.	As surface mulching, it increased soil available N, P and K by 11.92, 36.65 and 51.64%, respectively.	[28]
4.	Can carry on atmospheric nitrogen fixation with the help of free living bacteria in its roots.	[15]

plant coppices profusely from the stumps after slashing. To kill the weed, it must be slashed in short term interval to exhaust reserve carbohydrates and [29] recommended slashing four times a year in cocoa plantation, but [30] and [2] reported that slashing is not effective to control the weed. The most effective means of control for small infestations is to remove the entire plant including roots by hand weeding, but follow-up clearance every 2 – 3 month is needed because of rapid of new infestation from the seeds.

The negative effect of slashing and uprooting is that it opens the soil to the sun, which promote the exposure of seeds to light and this facilitate seed germination and creates ideal sites for recolonization by the weed [31]. Mechanical control is labor intensive and can be effective if infestations are small and accessible. A combination with other methods such as cultural and chemical control has been found to be economical and effective.

Controlled burning was the best control method of the weed [2]. Fire was found to be very effective at eliminating seeds, small and medium size of the weed [32], but [30] reported that in South Sulawesi Indonesia, burning without followed by planting any vegetation or mulch application resulted in infestation of hard seed plant of *Mimosa pudica*. Wu R et al. [33] reported that burning followed by planting signal grass (*Brachiaria decumbens*) effectively suppressed

the weed resulting complete eradication after three years. The cost of planting with grass species is expensive, therefore, this approach, if successful, is only likely to be used where intensive livestock production is conducted. Castillo and Moog [34] reported that planting of *Leucaena leucocepahala* in pastures reduced the weed population in Philippines. Torres and Paller [35] suggested planting legumes like *Calopogonium muconoides* and *Centrosema pubescens* and grass, *Setaria* sp. immediately after burning to reduce the weed infestation.

Chemical control using herbicides applied at seedling stage on early growth has given encouraging results. Pre-emergence herbicides such as diuron at dose 1.5 kg/ha and atrazine 2.0 kg/ha were effective to control of germination and establishment of the weed. Paraquat, glyphosate, and 2,4-D were the post emergence herbicides that resulted in in drastic reduction in the density of the weed [36]. In South Africa, the use of triclopyr, 2,4,5-T and tebuthiuron were consistently effective [37]. Triclopyr was more effective than glyphosate and that an acceptable level of control could be obtained with 2.5 dm^3/ha triclopyr and between 3.5 and 4.3 dm^3/ha of glyphosate was required for effective control [38]. In grassland area, triclopyr was more suitable to be used than glyphosate because triclopyr selectively kill broad-leaves plants like Chromolaena but did not kill grasses [39]. Efficacy of triclopyr can be enhanced when it mixed with asulam as opposed to individual products was applied. A 95% reduction of regrowth was achieved using a mixture of asulam and triclopyr, while over 89% reduction was achieved using glyphosate alone, however, glyphosate applied alone was more efficacious than when it mixed with asulam [40]. Tjitrosemito et al. [41] found 2,4-D, triclopyr and picloram are effective against Chromolaena in rubber plantations. Although widely used, efficacy of triclopyr is grassland area was not lasting, as at 90 days after spraying, Chromolaena became dominant plant again [39].

Although many herbicides have been reported to give effective results, but these generally fail to give long time of control, as reinfestation of cleared areas invariably occurs. Also, those herbicides require repeated applications with high dosages. Therefore most herbicide based control methods are not cost effective under most economical conditions in developing countries. Biological control, would therefore is expected as a means to reduce the vigor and reproductive capacity of the weed to a level at which other means of control become cost effective.

There are many natural enemies of this weed. McFadyen [42] identified 207 insect and 2 mite species that attacked the weed in America. Of these, about a quarter is specific to Chromolaena [43]. The moth *Parachutes pseudoinsulata* was the first agent to be deliberately introduced, from Trinidad to many countries. In the early 1980s, it was reported established in Sri Lanka and in the mid 1980s it had been established in Sabah Malaysia, but apparently did not causing much damage to the weed [6]. Introduction after mid 1980s resulted in establishment in some countries like Guam [44], Indonesia [6] and Ghana [45]. Attempts to introduce and establish *Parachutes pseudoinsulata* in some countries like Nigeria, South Africa, India Thailand and Ivory Coast were failed. The failures mostly caused by predatory pressures [5]. The moth was introduced into Indonesia in 1992 and has been established successfully in North Sumatera, but in Java and other Indonesia islands, it has not been reported to establish [20,6].

The second insect most widely introduced is gall fly (*Cecidochares connexa*). This fly was successfully reduced growth of the weed in Guam [44] and in India [46]. In 1995 the fly was released in Indonesia where it readily established and now it has established on all the major islands of Indonesia [47]. In Timor Leste, the gall fly established at most of the release sites and caused a visible reduction in plant height and density, however, control of the weed by the gall fly is limited by severe dry season and the widespread use of fire in clearing land for agriculture [8]. In South Sulawesi, the gall fly doesn't give good control. Although the fly is well established, *Chromolaena* still growing well.

5. CONCLUSION

The huge amounts of light and persistent seeds of Chromolaena making the weed can be dispersed easily far from its native places. In grassland areas, seeds germination and establishment are enhanced by open soil conditions during the wet season. The main negative impact of the weed in grassland ecosystem is reduced forage production for livestock. Although Chromolaena spread in grassland area has positive impacts, however, its negative impacts are far exceeding its positive

impacts. Control of the weed is very difficult and even after many years of research, problems of getting effective and cheap control remains unsolved.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/ 11308