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Comprehensive Review on Distribution, Socio-Economic Impact and its Management of Striga Hermonthica (Del.) Bent in Ethiopia

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***Abstract:** (Striga hermonthica (Del.) Benth.) is one of the world's most adversely affecting weeds of the family Orobanchaceae, which is a major global biotic threat to agriculture in sub-Saharan Africa, including Ethiopia. This review paper examines the prevalence, Socioeconomic impacts, and management options of Striga hermonthica (Del.) Benth. in Ethiopia. Generally to review about this paper various comprehensive literature search was conducted across different areas to come up the general conclusion these are Google Scholar, Web of Science, DOAJ and Science to be the review paper is relevant currently recent work is mandatory based on this idea the year of Studies of published article range between 2016 and 2025 were selected based on relevance and accuracy, quality and their findings were made into thematic areas of covering the prevalence, socioeconomic impact and its management Strategies of Striga hermontica bent in Ethiopia. Many management strategies have been developed to control this weed, including the use of resistant/tolerant varieties, sowing clean seeds free of Striga contamination, rotating cereal hosts with trap crops that induce abortive germination of Striga seeds, intercropping, and applying organic and inorganic soil amendments. This review recommended research on farmer participation, and the government of Ethiopia should conduct regular oversight to assess the prevalence and socioeconomic impacts of this species, implement appropriate protection measures, and prevent further introduction and spread of the striga species into areas not yet infested.*

***Keywords:** Socio-Economic Impact, Striga Hermonthica, Invasion of Alien Species, Ethiopia*

Nomenclature:
AM: Arbuscular Mycorrhizal
ISC: Integrated Striga Control
IR: Imazapyr-Resistant
N: Nitrogen
P: Phosphorus
KAI2: Karrikin-Insensitive2

I. INTRODUCTION

Striga hermonthica (Del.) Bentgrass is the most agriculturally damaging weed. Parasitic plants in the family Orobanchaceae suppress crop species, particularly Sorghum, Orobanche and Phelipanche are found in the Mediterranean region, eastern Europe, and North Africa. The genus comprises over 40 recognised species, with Striga hermonthica (Del.) causing the most significant damage. Benth. et Striga asiatica (L.) Kuntze.

This is due to the substantial economic losses these two species inflict on a staple cereal crop grown in SSA [31]. Additionally, it may affect biodiversity, human health and the environment, and the social and economic sectors, particularly in developing countries. Striga is thought to have originated in the border region between Ethiopia and Sudan (Nubia), where it causes significant yield losses across all cereal crops. Although striga is common in Africa, including many tropical countries, many aggressive alien species have been entering Ethiopia [15]. This makes its control too difficult. A large number of seeds will be returned to the soil and increase the seed bank if Striga plants are allowed to flower and set seed. The problem of Striga is related to the cropping system, which contributes to reduced soil fertility and increased Striga seed bank. Striga remains a severe problem, attacking finger millet, sorghum, and maize in northern Ethiopia [22]. Crop yield losses of 65-100 per cent due to Striga are common in heavily infested cereal fields in Ethiopia [18]. The annual yield loss and the geographic distribution of striga infestation are steadily increasing, particularly in Sub-Saharan Africa. Most available research indicates that the average yield loss from striga in sorghum exceeds 50% and, in severe cases, can result in complete crop failure, forcing farmers to abandon cereal production. The situation in many locations is worsening due to continuous cultivation of susceptible crops and limited application of agricultural inputs. Striga harmonica weeds mainly disseminate across farms through floods from nearby farms, farm tools, and/or via winds [38]. Allelochemicals produced in different parts of the plant can inhibit seed germination, initial growth, and biomass production in many plant species. It may also affect native vegetation indirectly through changes in soil properties [11]. In addition to biodiversity loss, Striga can interfere with seed germination and early growth and reduce the effectiveness of development by blocking irrigation canals and imposing limitations on sustainable development, poverty mitigation, and food security in Ethiopia. The aim is that the disaster impacts arising from this weed are often considered insufficient to capture managers' attention (since very little is known about the threats and dispersal of Striga harmonica in Ethiopia), and/or that the impact of this invasive alien species is often misinterpreted. Striga has spread widely across the country, but it is still not widely recognised as a chronic

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environmental problem, except in a few parts of Ethiopia, such as Oromia and Somali. Striga hermonthica is the primary species of concern in Ethiopia, affecting biodiversity, agricultural lands, rangelands, waterways, lakes, rivers, power dams, and roadsides, with ecological consequences [15]. The parasitic weed problem has been exacerbated by an ever-increasing population pressure, associated global climate change, frequent cultivation of host crops, and reduced soil fertility [25]. Compared with other weed species and non-parasitic weeds, parasitic weeds are difficult to control because of their life history. The management of parasitic weeds is hindered by their high fecundity, dispersal efficiency, persistent seed bank, and rapid responses to changes in agricultural practices, which enable them to adapt to new hosts and become more aggressive against rarely encountered resistant cultivars. Their management has been tested using several control methods, but to date, no economically viable, feasible, or universally reliable method has been identified. There is also some knowledge of the weed Striga hermonthica. This paper is a helpful resource for recording and organising information on the prevalence, Socioeconomic impact, origin, and management strategies of Striga hermonthica in Ethiopia.

II. METHOD OF REVIEW

Literature was searched in depth across several professional academic databases, including Google Scholar, Scopus, Web of Science, DOAJ, and ScienceDirect, to identify relevant peer-reviewed articles, books, reports, and documents published between 2016 and 2025. Unpublished literature from the Agricultural office and local NGO publications will be used as sources to disseminate significant, relevant, and appropriate information to the reader.

A. Origin and Domestication of Striga Harmonica

S. hermonthica is believed to have originated in Africa, along the border between Sudan and Ethiopia (currently referred to as Nuba), where it causes severe losses in most cultivated crops, impacting the livelihoods of over 100 million African people. Striga has been recorded in more than 40 countries. In Ethiopia, Striga is the main biotic limitation and a severe menace to subsistence food production. Striga is a Latin word meaning ‘‘which’’. It is known as which weed because it causes stunted growth and early discolouration of crop leaves before their emergence. There are many Striga species which are economically significant. Among the most financially important Striga species worldwide are purple witch weed (S. hermontii hica (Del.) Benth.) and Asiatic witch weed (Striga asiatica (L) Kuntze) [15].

Eleven of the more than 40 species in the genus Striga are thought to be parasites on crops. Plant species origin is typically indicated by the frequency and degree of genetic diversity of a species in a given geographic location, where more forms develop and specialised relationships are observed. The highest diversification of both the parasite population and the two crops that Striga readily infests, sorghum and pearl millet, is found in the vast tropical savannah that lies between the Nubian hills of Sudan and the Semien Mountains of Ethiopia. Both pearl millet and sorghum are known to have originated in this region, and it's possible that these two species still reside there, as do Striga species affecting cereals, namely Striga hermonthica and Striga asiatica. It's likely that Striga gesnerioides, a species that has evolved specifically to serve as a pest of legume crops, started in western Africa. Presently, Striga is found in nearly all regions of sub-Saharan Africa, except in areas with excessive rainfall or at high elevations where temperatures may be too low for the parasite to flourish. Striga is particularly severe in barren, nutrient-depleted soils with low levels of organic matter [15]. The species with the broadest geographic range is S. hermonthica. It is the species that damages crop the most because of its large plant size and compulsive outcrossing tendency. Much of sub-Saharan Africa is home to S. hermonthica, with Western, Central, and Eastern Africa having the highest incidence. It is also present in parts of the southwestern Arabian Peninsula, located on the other side of the Red Sea. The most extensive range of S. asiatica is found in eastern and southern Africa. In addition to the US and Australia, it is found in Asia, primarily in southern India. Globally, Striga gesnerioides is found in Africa, the Arabian Peninsula, the Indian subcontinent, and the United States. The legume crops farmed extensively in western Africa, particularly cowpeas, are the most severely economically impacted by this species. Because Striga gesnerioides and Striga asiatica are self-fertile, there is apparent genetic variety seen in both parasitic specialization and various morph types. Compared with the obligatorily outcrossing Striga hermonthica, they seem far less variable [5].

Humans have transported thousands of plant species to areas far from their natural habitats, intentionally or accidentally (e.g., for agroforestry, horticulture, forestry, and animal farming). However, invasions by IAPS are among the most significant threats to Earth's ecosystems and their services. The predominant species is Striga hermonthica, which is most severe in the severely degraded regions of the country's north, northwest, and east, including Tigray, Wollo, Gonder, Gojjam, North Shewa, and Eastern Hararghe, because of its wide geographic distribution and devastating effects on millions of people's livelihoods [36].

B. Taxonomic Description of Striga Harmonica

Striga spp. are annual, photosynthetically active, root hemiparasitic plants that feast on other plants for growth (Rich, 2020b). Its growth system is complex and closely associated with its host. A single Striga plant can produce up to 500,000 seeds, capable of remaining in the soil for 20 years under optimum conditions [17]. The lifecycle of Striga operates simultaneously with that of its host and requires mechanisms that harmonise the lifecycles of both the host and the parasitic plant. Its lifecycle typically involves germination, host attachment, formation of haustoria, penetration and establishment of vascular connections, nutrient accretion, flowering, and seed production [5]. These seeds germinate only in the presence of host-derived chemical signals, strigolactones, which are usually accompanied by a period of preconditioning that requires warm weather and moist soil. A haustorium forms, connecting the host plant to the parasite. This allows water and nutrients to flow between the Striga and the host plant, thereby damaging the host. However, this parasite cannot survive independently at any stage and depends solely on the host plant for survival and growth (Cimmino *et al*., 2018). It takes about 10 weeks for Striga spp. to complete its life cycle after egression, and this completion usually occurs after the host plant has been harvested [5]. Striga hermonthica is a high-crossing species, with noticeable heterogeneity within an area [23]. This unique characteristic of dispersal has contributed to its genetic modification. It has facilitated the spreading of the parasitic plant depending on the availability of dispersal agents [21]. Within the Striga hermonthica population, genetic diversity is primarily associated with host-specific traits [19]. The variation process within the parasite accounts for the potential for resistance during its accommodating stage. A typical example can be found in a particular cultivar of crops planted in the presence of the S. hermonthica species. The attributes mentioned above are among the reasons the parasite poses a significant threat to the plant host.

latera linflorescence with bright pink, rose-red, white, or yellow colour. The weed depends on its host during parts of its life cycle, namely germination, flowering, and reproduction. The root system of Striga is vestigial, in which the germinated seed radicle produces a haustorium instead of a characteristic angiosperm root to interact with the host. The seeds are very tiny, measuring 0.15-0.3 mm in diameter. However, many biological aspects of Striga, including photosynthesis, respiration, transpiration, water relations, the causes of severe yield reductions, morphology, and the function of the haustorium, remain incompletely understood. S. hermonthica has a wide host range; it is the most ubiquitous parasitic weed of staple crops, namely maize, sorghum, pearl millet (Pennisetum glaucum), upland rice, tobacco, and sugarcane. Its seed germinates only after being exposed to favourable moisture and temperature conditions for several days (preconditioning) [15].

C. Mechanism of Striga Seeds Dispersal

The mechanisms of Striga seed dispersal by wind, animals, water runoff (flood), and contaminated crop seed with Striga seeds dominate, because farm crops are harvested when the Striga weed has flowered. When the animals move, they carry the seed of Striga on their bodies, mud feet, and feathers, so easily dispersed. Farm machinery was rated lower because most farms have fewer tractors and combine harvesters. They use their hand-farm tools, which results in less dispersal [15].

D. Dispersal of Striga and Infestation in Ethiopia

Striga. A significant biotic factor and substantial danger to the production of food for subsistence in Ethiopia. Previous records state that the weed is indigenous to the nation. Only 7 of the approximately [12] Striga species thought to exist in the country have been officially recognised. Striga aspera on maize; Striga asiatica on sorghum and maize; Striga gesnerioides on sweet potatoes; Striga forbesi and Striga pinatifida on wild vegetation are the following, in order of significance: Striga hermonthica on sorghum, maize, millet, and other cereals such as tef [15]. Striga hermonthica is the predominant species, according to Fasil and Parker. It is most severe in the severely degraded areas of the country's north, northwestern, and eastern regions, including Tigray, Wollo, Gonder, Gojjam, North Shewa, and Eastern Hararghe. Given its widespread distribution, Ethiopian scientists believe that striga poses a greater threat to the nation than to other SSA nations. The dispersal of Striga Harmonica in Ethiopia is extensive, affecting many ecosystems, including cultivated and non-cultivated land, roadside areas, grazing areas, rural villages, riverbanks, wetlands, forests, and urban areas. It causes the most significant loss of biodiversity. Striga Harmonica has usually been deliberately introduced into various localities in Ethiopia (particularly urban settings) as an ornamental shrub. It has rapidly spread through birds and animals that eat its fruits but cannot digest its woody seeds [15]. It is commonly found in East and Southern Africa, where it occurs at elevations below 2000m and often invades previously disturbed areas, such as forests that have been logged and areas cleared for agriculture. Human-made and natural disturbances interact to facilitate the introduction and spread of invasive alien species. This process enables the plant to spread more rapidly than other weed plants. Its use for fencing also contributed to its dispersal within the country [15]. The ability of L. camara to rapidly colonise disturbed land (in countries like Ethiopia, where activities such as logging and agricultural clearance are everyday occurrences) may also facilitate its dispersal [15]. striga harmonica L. has biological attributes like a high production of fruits each year (prolific seed production) and duration production of (which fruit is throughout the year conditions are favorable such as adequate light and moisture), its ability to propagate vegetative by a process called layering where horizontal stems take root when they are in contact with moist soil better competitive ability compared to native flora, widespread geographic range (wide ecological tolerance) contributed to the success of its dispersal [36]. In addition to its biological attributes, the rapid spread of its Seed fruit by birds (the predominant dispersers) and animals that eat its fruit may have contributed to its dispersal after its careful introduction into various localities in Ethiopia. Transportation of seeds by running water within the country may also contribute to their spread [15].

III. AGRO-ECOLOGY OF STRIGA HARMONICA.

Agroecology for the growth of Striga hermonthica mainly in semi-arid tropical regions: Striga typically favours infertile soils found in open grasslands and savannahs. Their seeds remain dormant until it rains, since they are accustomed to hot, dry weather. S. asiatica has been documented from a variety of climate zones, including mild temperate regions (usually where it is dry or at least seasonally dry) and seasonally dry tropics and subtropics, while likely being most suited to dry, tropical environments. At the same time, S. Gesnerioides has naturalised in Florida, a subtropical and occasionally moist region, and S. Hermonthica and S. Hermonthica both favour hot, arid, or semi-arid climates [28]. The parasite poses the greatest threat to agricultural systems with short or no fallow seasons, low soil fertility, and limited use of fertilisers, herbicides, improved seeds, and modern management practices. [28] reported that temperatures ranging from 25 to 35°C are necessary for Striga seeds to germinate. 35°C is the ideal temperature for germination of S. hermonthica and Striga asiatica. Unlike many other Striga species, Striga asiatica can withstand colder temperatures, which is why it has thrived in temperate climates outside of its natural habitat. The seeds of this plant can be stored at -7°C without losing their viability. When the average daily temperature is 22°C, plants reach maturity. This species may be able to expand its host range and geographic range due to environmental flexibility. S. hermonthica can withstand temperatures ranging from 40/30 °C to 25/15°C during the day and night. Infestations of witchweed are common across parts of Africa, especially in Ethiopia. A Striga infestation may cause a slight reduction in output and, in certain situations, total crop failure. Heavily infested farms frequently experience losses of 65–100% in countries like Ethiopia and Sudan. Ethiopia's northern region is heavily infested, particularly in Tigray, parts of the Amhara region, East Hararghe, Somalia, and the western Gambela region. Ethiopia is classified as a strongly infested country at the African level [3].

IV. ECONOMIC IMPORTANCE OF STRIGA

Striga species are a significant bottleneck in the production of cereals, including finger millet, pearl millet, and maize. The parasitic effect inhibits deterioration in germination, yield, and growth of food crops. The harmful effects of the parasite can be evident even before it emerges from the soil, discouraging control efforts for farmers. It has been calculated that over 50 million hectares of tillable soils under cereals cultivation, including maize, have been infested by Striga spp. [6] Several researchers reported Grain losses resulting from this parasite have been reported to be up to 75%, depending on the host affected, average weather conditions, varieties cultivated, degree of the infestation, and the nature of the soil. The decrease in grain harvest of the enhanced cultivar has improved to 90%, as reported by [5].

A. Socio-Economic Impacts of Striga Hermonthica (Del.)

Socio-Economic Impacts: Striga hermonthica (Del.) was introduced to Ethiopia via wind, birds, and insects, owing to its prolific seed production and ease of dispersal. It escaped cultivation and became a pest, raising concerns in social, ecological, and economic contexts. Currently, it has spread almost nationwide. According to a recent literature review of Striga, food scarcity is causing annual financial losses exceeding 10 billion USD [27]. Striga hermonthica, among diverse Striga species, causes the most devastating losses to cereal crops, including maize. Similarly, according to household respondents, Striga hermonthica has marked effects on the growth and yield of their host crops. The respondents said that during Agronomic practices, it is difficult to thin sorghum seedlings because Striga is attached to the sorghum roots. This assessment agrees with [6], who explained that the Striga life cycle is subterranean; it grows entirely at the expense of its host, and the parasite inflicts most of its damage during this phase. Symptoms displayed by infected hosts include stunting, toxic effects, expansion, reduced wilting, chlorosis, reduced photosynthetic rate in internodes, and decreased growth and yield [20]. Striga is not edible; it is poisonous to livestock, causing loss of appetite, frequent urination, dehydration, and yellowing of the inner mouth and eyes. Hairs are lost from the skin, the mouth and eyes swell and ulcerate, and animals may die in one or four weeks. Several problems associated with Striga include its status as an annual weed that rapidly invades habitats, negatively affecting them. attacks include invading cultivated land, rapidly taking over valuable grazing lands, and dense growth that inhibits grasses and other valuable forages beneath its canopy.

B. Agriculture Loss

In agricultural areas, Striga can become the dominant undergrowth family, displace other native species and reduce biodiversity. The formation of dense, thick Striga can significantly reduce crop production and yield on cultivated land. Striga is a parasitic weed that produces allelopathic chemicals (toxins) that interfere with other crop species. Striga invades the susceptible host while increasing the Striga soil seed bank. Crop exudates stimulate striga seed germination, further reduce yields, and alter the microenvironment (e.g., light, temperature) by forming dense canopies [33]. The tiny Striga seeds have evolved a host-detection strategy by perceiving host-released signalling molecules, mainly the phytohormone strigolactones (SLs), which trigger their germination [11]. The well-known reason plants release SLs is to communicate effectively with the surrounding arbuscular mycorrhizal (AM) fungi for symbiotic interactions [8]. In the parasitic plant Striga, the receptors responsible for SL-induced seed germination are Striga hermonthica hyposensitive to light (ShHTLs), a group that is assumed to be evolutionarily derived from a karrikin-insensitive2 (KAI2) receptor and to have arisen through gene duplication, with functional replacement by SLs [6]. Despite its recognition as one of the world's worst invasive alien species, information on Striga's ecological interference with the growth and establishment of native plants, especially agronomic crops, is limited in Ethiopia. Some of the work done in voracious places on agriculture has been studied in some parts of the world [7]. It may indirectly affect crop production through heat, as it serves as a host for many insect pests that can affect human health. In addition to its effects on root and shoot growth, biomass, and host for vectors, the weed can affect the mustering of cattle (by out-competing native pastures that are better feed for the cattle), thereby disturbing agriculture.

C. On Biodiversity Loss

The endemic parasitic witch weeds (Striga spp.) The most significant adverse impacts are those that directly change ecosystems. It has cascading effects on resident biota (plants, animals, and microorganisms). Exotics can disrupt ecosystems by altering system-level flows, the availability, or the quality of nutrients, food, and physical resources (e.g., living space, water, heat, or light). Many studies suggest that introduced ecosystems can increase habitat complexity and heterogeneity, which tends to raise or lower abundances and/or species richness. Difficulty tends to have the opposite effect on ecosystem services. Ecosystem services can be characterised into four main service areas.

(1) Provisioning service (e.g. food, freshwater, fibre, fuel, genetic resources.

(2) Regulating services (e.g. air quality regulation, climate regulation, water regulation).

(3) Traditional services are nonmaterial benefits (e.g. aesthetic values, recreation/tourism, spiritual/ religious values) [4]. Supporting services. Overarching, indirect, and occur on large temporal scales (e.g., photosynthesis, primary production, nutrient cycling [29]. They are particularly damaging in geographic or ecological islands that are rich in endemic species. Invasive plants smother, outcompete, and displace indigenous species, thereby altering the composition and functioning of entire ecosystems. Phytochemical studies of this plant revealed the presence of terpenes, saponins, cardiac glycosides, alkaloids, anthocyanins, coumarins, tannins, and flavonoids. These allelochemicals (e.g., phenolic acids and alkaloids) inhibit plant germination, growth, and yield [1]. The other system of Striga affects the biodiversity through competition for resources (e.g., water, nutrients, sunlight). In addition to allelepathy, it has a fast growth rate and an inedible nature (due to its unpalatability, the weed experiences relatively little pressure from natural predators compared to those that have evolved in their native environment) [14].

The effect of Striga on human health can be direct or indirect. Feeding on striga seeds has proven fatal, and this can be considered a direct consequence of striga harmandiana for human health. However, this may not always be true, as children and adults often consume the fruits of Striga harmandieri L. camara without adverse effects in Ethiopia. Furthermore, in Sudan, it is traditionally used orally as an abortifacient, for pneumonia and fungal infections, as a contraceptive, as a mosquito repellent, and as an anti-cancer and anti-diabetic agent in western Sudan [4].

V. MANAGEMENT SYSTEM OF STRIGA HERMONTHICA (DEL.)

There are different management options available, including cultural practices, chemical control, the use of biological agents or natural enemies, and host plant resistance. Several methods have been implemented and adopted for control of striga a lot methods potentially management approaches developed to control this weed include using resistant/tolerant varieties, sowing clean seeds that are not contaminated with Striga seeds, rotating cereal hosts with trap crops that induce abortive germination of Striga seeds, intercropping, applying organic and inorganic soil amendments such as fertilizer or manure fumigating soil with ethylene, hoeing and hand pulling of emerged Striga, applying post emergence herbicides, push-pull technology and using biological control agents. But their adoption depends on the availability of resources and skills among smallholder farming communities. Traditional practices such as hand-pulling, crop rotation, intercropping, trap or catch cropping, push-pull technology, and soil fertility improvement (nitrogen fertilisation) are employed. Chemical management practices, for example, weedicide (imazapyr), genetic control, resistant crop varieties, suicidal germination, biological control agents (such as fungi and bacteria), and certain insects have been used [24].

Striga is a noxious weed that is a particular problem in areas with low moisture and where soil fertility is eroding due to increased population pressure, reduced fallow periods, and minimal use of organic or inorganic fertilisers. Most importantly, it primarily affects the livelihoods of poor subsistence farmers in Ethiopia's cereal-based agricultural systems. Prodigious seed production, prolonged seed viability, and the subterranean nature of the early stages of parasitism make the control of the parasite by conventional methods difficult, if not impossible [14].

A. Phyto-Sanitary Measures

The sanitary practices possible solution at different levels are; use of weed free nursery site, locating nursery sites around the source of water canal to reduce spread of weed seeds, control of alternate hosts in nursery site, infested field and banks of water canals, minimizing the movement of infested soil through cleaning of farm implements (hoes, spades, etc.), farm machineries (tractors and other transport vehicles), and harvesting materials; controlling irrigation water free movement from field to field to prevent spread of the weed seeds, preventing free movement of grazing animals on infested fields, avoiding the use of hay from infested plants and fields; treating manure i.e., composting, and burning the stub bles of crops and weeds in infested fields. In general, these phyto-sanitary measures are suggested to reduce the production of new seeds and their dispersal [9].

B. Soil Fertility

Striga grows best in less fertile soil; increasing soil fertility would provide a double benefit, boost yield and reduce Striga infestation. Mulching with various crop residues and organic manure, as part of good soil management practices, has proven effective in preventing Striga. As the amount of organic matter in the soil increased, the prevalence of striga infestation decreased. Organic or inorganic soil amendments may boost suppressiveness to Striga spp. and improve the soil's physicochemical properties, thereby increasing the yield of succeeding cereals, as soil microbial biomass thrives better in a medium rich in organic matter.

VI. PHYSICAL, CULTURAL AND/OR MECHANICAL CONTROL

A. Cultural Management Various

Cultural management strategies have been proposed to control Striga weeds in maize, sorghum, pearl millet, and rice cultivation. These strategies aid in minimising Striga seed in the soil, enhancing soil productivity and maturation, and slowing the sprouting and growth of seedlings [34].

B. The Strategies Include

Recently, cover cropping and the use of chemicals with varying Striga resistance were established to alleviate the impact of Striga on maize and rice [30].

i. Intercropping

Intercropping of cereals with legumes in areas where striga incidence is severe, intercropping of sorghum with

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legumes such as green gram or mung bean [Vigna radiata (L.) R. Wilczek], cowpea, soybean and groundnut help in suppressing them through suicidal germination and improving soil fertility. Delaying crop sowing may reduce parasitic weed infestation. Early planting, preceding rainfall, also minimises Striga plague in semi-desert regions, which often occurs a few months after cultivation [23].

ii. Hand Weeding

The Striga are widely hand-pulled as a traditional, readily available control method among farming communities, but are found to be late and ineffective at reducing immediate damage. However, they are necessary for limiting further increases in the seed bank. The parasitic weed shoots must be removed before seed set and discarded immediately, as they can continue to develop flowers and disperse seeds. It requires frequent practice, which results in high costs, substantial mechanical damage to crop plants, and a significant reduction in host crop yield [35].

C. Biological Control

Biological control of Striga was attempted in Ethiopia many years ago, but since then, no progress has been made. This biological option is primarily used to control root-parasitic weeds in annual crops. Conventional weed control methods are challenging to implement due to the intimate physiological interactions these weeds have with their host plants. This method reported that biocontrol agents are typically highly aggressive, host-specific, easy to produce in large quantities, and diverse in the number of isolates. Biological control using microorganisms is currently emerging as a crucial component of the integrated management of Striga [35]. Moreover, biological control techniques are typically inexpensive, self-sustaining, and free of unfavourable aftereffects. For example, Fusarium oxysporum isolates in Striga management in sorghum fields in East Africa have not yet been reported or implemented. Therefore, there is a need for integrated management of the parasite through host resistance and application of FOS to enhance production and productivity of sorghum and related cereals affected by Striga. There are no reports of adverse effects of FOS on sorghum or related cereal crops. In fact, FOS has been reported to increase the abundance of arbuscular mycorrhizal fungi in the rhizosphere of sorghum, thereby enhancing crop growth and development [23].

D. Chemical Control

Chemical control may be used to initiate germination of striga seeds in the absence of a suitable host and to deplete soil seed reserves with imidazoline herbicides such as imazaquin, imazapyr, and pyrithiobac [39]. Previously, this method of control was not feasible due to its high cost, the need for an appropriately applied protocol, and the requirement for an easy-to-use formulation containing strigolactones produced by several chemical processes that are unstable in the field. This strategy is attractive because it quickly reduces the Striga seed bank. Even though several methods have been developed for the suicidal killing of this parasite, their application under field conditions is limited because they are expensive, lack a properly implemented protocol, and have formulations that are not easy to use [14]. This practice is most widely implemented in Kenya, where one imazapyr-resistant (IR) maize hybrid has been registered for commercial release. The IR maize hybrid reduced striga expression overall, increased yields, and increased farmers' net returns by more than 50%. Moreover, the application of 2,4-D and metryne was practical.

E. Use of Bioinoculants as a Biocontrol Agent

Exploring the use of microorganisms is an efficient strategy to combat environmental degradation while enhancing sustainable agriculture and soil health. The quest for an eco-friendly approach to reduce the adverse effects of agrochemicals on plants and soils has led to the discovery of microbial formulations to improve crop yields [10]. These microorganisms include bacteria and fungi. The application of soil microorganisms, such as rhizobacteria and arbuscular mycorrhizal (AM) fungi, has significantly decreased cultivation, production, and attachment of Striga [16]. Inoculating AM fungi on maize cultivars reduced the incidence of S. hermonthica and increased nitrogen (N) and phosphorus (P) [32]. Enzymes, such as xylanases, pectinases, and amylases from Bacillus and Streptomyces species, can directly degrade Striga seeds. In contrast, Rhizobium isolates can solubilise insoluble phosphate and make it available to plants [26]. Moreover, soil microorganisms can combat Striga by producing amino acids like methionine, leucine, and tyrosine or releasing secondary metabolites, including trichothecenes and sesquiterpenoids "β-lactone" derivatives, and anthranilic acid, which could cause strigolactone perception to be hampered [37]. Applying soil microorganisms, such as plant growth-promoting rhizobacteria and AM fungi, is a more effective and environmentally friendly method to eradicate Striga [32].

F. Integrated Management of Striga

Striga control through a single management option has not been found effective across locations and over time. However, an integrated Striga management approach currently offers the best opportunity to reduce impact at the farm level. An integrated Striga management system, currently playing the most significant role in reducing impact at the farm level. Control is most effective when a range of practices is combined into an integrated Striga control (ISC) program that provides sustainable control across diverse biophysical and socio-economic environments [11]. Furthermore, cereal-legume crop rotation combined with germination stimulants can significantly reduce the number of parasite seeds in the soil [14]. According to an experiment carried out by [2], the combination of P fertiliser and a resistant variety inoculated with Brandyrhizobium has been able to reduce Striga gesnerioides and increase cowpea grain yield. The use of Striga-resistant and herbicide-resistant maize with Legume suppressed Striga seed germination and reduced the Striga seedbank in the soil [13].

VII. CONCLUSION AND RECOMMENDATION

Striga spp. are endemic parasitic weeds in sub-Saharan Africa, whose geographic range and infestation levels are gradually expanding, significantly reducing crop

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productivity. Striga is a significant biotic limitation and a subspatial threat to the production of subsistence food in Ethiopia. One of the predominant species adversely affected, Striga hermonthica, is most severe in the country's north, northwest, and east, including Tigray, Wollo, Gonder, Gojjam, North Shewa, and Eastern Hararghe. The severity of striga is increasing on socially, politically, and economically important crops across Ethiopia. Farmers do not utilise management options well, and no harmonised parasitic weed management strategy has been well developed in the country. In the absence of simple, direct parasitic weed control measures, there is a need to enhance farmers' knowledge and develop an integrated management program. Striga hermonthica is becoming a challenge for sorghum production. As a result, local people become food-insecure, thereby affecting their socioeconomic activities. Therefore, a detailed investigation should be sustained in the future to cover large areas. Invasive alien species, such as plants, are introduced purposely or unintentionally outside their natural habitats, either naturally or through human activities. Invasive alien species are found across all taxa (groups of organisms) and are present worldwide in all ecosystems, including urban green spaces, with significant economic and social consequences. But there are management blocks to implementing such strategies. There is a need to practice will make preferable management options, to share knowledge with farmers, and to establish a linkage between research and extension for coexistence. Parasitic weed management requires strategic approaches that account for the biology of the weeds and the socio-economic aspects of a particular agro-ecology. At all, limiting the spread of parasitic weeds, mitigating their damage to host crops, and promoting food security for future generations are critical. Mechanical, chemical, and fire regimes, as well as biological control methods, are some methods used to manage the invasion of particular species, such as water hyacinth.

The mechanisms of management systems could be important for controlling IAPS. Prevention, integrated management strategies, and the use of the species as a control measure for the noxious, invasive alien species Striga hermonthica in Ethiopia. Therefore, the following recommendation will be forwarded,

- It needs to be very carefully pointed out, point by point, by one collaborator of various stakeholder actions at multiple levels, involving the Retrieval Striga harmonica.
- Sustainable and multidisciplinary studies are needed regarding the history, properties of invasiveness, and impacts of the species in relation to ecological effects on ecosystems and socioeconomic consequences.
- Countries with IAPS share information and work together to control the transfer of IAPS from one to another.
- Providing training for the community on how to use the species to improve the biophysical and socio-economic environment.
- Striga controlling systems/plan such as Striga-free seeds, crop rotation, legume intercropping, moisture conservation, hand weeding before flowering and the use of different mechanisms to restrict the distribution of Striga from one field to another. prevent erosion, and use it as a live fence around farmsteads and home gardens.
- Removing it before seed production is a significant means of encroachment into uninvited areas.
- Determination of the beginning level for decline in biodiversity and the identification of management barriers to invasion.

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After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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