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A Review on the Effects and Managements of Cuscuta Campestris in Ethiopia

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Abstract
Cuscuta *campestris* is native to North America of the family Cuscutaceae have a very distinct appearance, consisting mainly of leafless, glabrous, yellow or orange twining stems and tendrils, bearing inconspicuous scales in the place of leaves, known for its notorious role as environmental, medical, and agricultural hazards. Cuscuta like many troublesome weeds has different names in different localities. Common names in addition to dodder include love vine, strangle-weed, devils' guts, gold thread, pulldown, devilsringlet, hellbind, hellweed, devilshail, and hailweed. It is believed to have been introduced into India and Australia from North America and in the last few years the weed has emerged as the seventh most devastating weed in Africa, Asia, and Australia. It is also spread in contaminated crop seed but this should be avoidable by sieving, as the seeds are appreciably smaller than even the small seeded linseed varieties grown in Ethiopia. The two species most likely to be encountered in Ethiopia are both introduced. The common and most serious in agriculture is C. campestris. The second one is C. eplinum, which is very similar superficially to C. campestris except for slightly paler yellow stems and slightly larger flowers. Integrated weed management (IWM) aims to diversify weed management strategies to reduce the reliance on herbicides. This includes the integration of a wide range of cultural control options such as cultivations, drilling date, cropping choice, biocontrol, mechanical and other physical control. The aim of this review is to provide general information about the physiology, distribution, and management of cuscuta. Control of cuscuta has been tried by various methods, but no single management option would be adequate to manage cuscuta, and there is a need to integrate various management options. Successful management of this weed can only be achieved by an integrated approach with biological control as the key element.
Keywords: Cuscuta, dodder, management, noxious
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INTRODUCTION

Species in the genus Cuscuta (commonly called dodder) are rootless, effectively leafless, only minimally photosynthetic, and totally dependent on their host (Kelly et al., 2001). They are obligate parasitic plants with approximately 170 different species distributed throughout the world (Holm et al., 1997). They are stem and leaf parasites that depend entirely on the host plant, thus reducing the growth and yield of the host. They infect many broadleaf crops, ornamentals and weeds and a few monocot crops. Dodder like many troublesome weeds, has different names in different localities. Common names in addition to dodder include love vine, strangle-weed, devils' guts, gold thread, pulldown, devilsringlet, hellbind, hellweed, devilshail, and hailweed.

They are obligate holoparasites (Costea and Tardiff, 2006; Mosango et al., 2001), typically exhibiting broad host ranges, and inflict serious damage to many crops, including forage legumes (alfalfa, clover, lespedeza), potato, carrot, sugar beets, chickpea, onion, cranberry, blueberry, and citrus (Dawson et al., 1994).Cuscuta *campestris i*s the most widely distributed dodder species worldwide and the most important Cuscuta species, attacking a wide range of species, including vegetables, fruits, ornamentals and woody plants. It is reported as a weed in 25 crops in 55 countries (Lanini and Kogan, 2005).

The genus *Cuscuta* is usually placed in the family Convolvulaceae a family already notorious for such serious weeds as field bindweed (*Convolvulus arvensis* L.), Morning-glory (I*pomea* spp. L.) and many others. *Cuscuta* is a large genus of over 100 species which are often difficult to identify. The taxonomic characters of the genus are confined almost entirely to the flower, fruit, and inflorescence, as the vegetative parts of dodder show great uniformity. Recently, Dawson (1984) observed that there is a difference in stem morphology that can serve to separate *Cuscuta planiflora* from *C. campestris* and *C. indecora*. This vegetative difference is completely consistent, and can be used to separate the three species into two distinct groups without reference to floral characteristics.

It is widely distributed and naturalized in the tropics but its exact native range remains obscure and its center of diversity is believed to be most probably in North and South America (Parker and Riches, 1993, USDA-ARS, 2010). Dawson et al., (1994) reports that the weed is now widespread across temperate, sub-tropical and tropical regions of the world including Nigeria (Akobundu and Agyakwa,1998).

Parker and Riches,(1993)reported as its powerful metabolic sink effect, the damage to infected hosts can be severe, to the extent of total crop loss. Crops most seriously affected include: lucerne in North America, the former Yugoslavia and many other countries; niger seed in India and Ethiopia; sugarbeet in the former Yugoslavia, Italy and eastern Europe; and chrysanthemum in Australia, the Canary Islands and Ethiopia). There are many other serious local infestations. Although tomato is not always affected, it is seriously attacked by *C. campestris* in Spain and Israel (Tei et al., 2003).they also showed that Crop losses have rarely been measured, but there are estimates of 57% reduction in lucerne forage production over a 2-year period, and reductions of up to 40% in root weight and 3.5 to 4 tons of sugar per hectare in infested sugar beet. Mishra et al. (2007) compared the susceptibility of different crops in India and measured yield losses of 86% in niger seed, 82% in greengram, 67% in sesamum, 48% in soyabean, 27% in black gram, 25% in pigeon pea and 18% in groundnut, but none in rice or cowpea.

Biological invasions are attracting extensive attention from ecologists because of their significant ecological impacts and economic costs worldwide. They are increasingly recognized as a key problem of conservation of biological diversity (Reichard and White, 2003). Invasion by plant species poses a major threat to native plant communities and alters fundamental structures and functions of ecosystems. Recently, it has been proofed that some invasive alien plant species (IAPS) are spreading at an alarming rate and exerting negative impacts on agricultural lands, rangelands, national parks, waterways, lakes, rivers, power dams, roadsides and urban green spaces in Ethiopia (EARO, 2003).

Cuscuta species, (dodders), are much less frequent in Ethiopia than the mistletoes and fewer than ten species have been recorded with any certainty. One of the most striking indigenous species is the thick vined *C. kilimanjari*, unusual in being a forest species. Other species occasionally encountered on wild vegetation include *C. pedicilleta*, *C. planiflora*and *C. hyalina.*

Many species, because of the similarity of the size of the seeds to those of commercial crops, especially legumes and flax, have been introduced in seed lots to countries where they did not at first occurred. The North American *Cuscutagronovii* is a weed in several European countries. *Cuscuta campestris*, from the same homeland, has reached Africa, Europe, South America, China and Australia. *Cuscutasuaveolens* from South America has invaded all other continents. Two European dodders, *Cuscutaepithymum* and *Cuscutaepilinum*, are now found nearly throughout the world; and an Asian species, *Cuscuta approximata*, has been reported from England.

Recent survey reports indicated that *Cuscuta* parasitizes young and stumped coffee in the Jima-Melko, Teppi and Bebbeka Coffee State Farms. Noug and linseed are the most known economic crops hosting *Cuscuta campestris* and *Cuscuta epilinum* respectively. The crop mostly affected is noug and this creates problem for the Ethiopian Oilseed and Pulse Crops Export Corporation (EOPEC) who find a large proportion of farmer grown weed sample to be contaminated, resulting in price penalty when the seed is exported (EARO, 2004d).In Ethiopia different authors reported effect of this weed from different part of the country. So reviewing those report and compile in one article is very important for different beneficiaries.

Distribution

C.campestris is a mainland North American species which has been distributed very widely around the world, mainly by means of contaminated crop seed and fodder, especially of lucerne. It is also apparently native to some Caribbean islands but the exact limits of its native range remain unclear (USDA-ARS,2008), and it may well have been introduced there. As an introduced species, it is most common in temperate and sub-tropical regions and least abundant in the tropics of Central America, Africa, South-East Asia and the Pacific Ocean.

Biology of *Cuscuta* spp.

Seed and germination

A high percentage of seeds of dodder are 'hard seed'. Such seeds remain dormant because the seed coat excludes both water and oxygen. They will not germinate until the hard seed coat is broken. Because of the large number of seed produced and the dormancy imposed by the seed coat, dodder seed is capable of remaining in the soil for many years. Once a field is infested, a dodder problem can be expected each year for many years. The length of time dodder seed will remain in the soil is not known, but periods of 10-20 years may be possible. The flower of dodder has only 4 ovules, and there may be fewer but never more than 4 seeds per flower. Dodder seeds are gray to brown, irregularly round, and finely rough in surface texture.(Taye T, Rezene f, Firehun Y 2007)

Attachment to the host

The embryo of dodder lacks cotyledons and the seedling does not have a root cap, root hairs, or other normal root tissues. A dodder seedling consists of a rootless and leafless stem. Each seedling emerges from the soil as an arch-shaped stem, which straightens and begins to rotate counter-clockwise. Upon contacting any elongated object the seedling twines about it. If the elongated object is the leaf or stem of a suitable host plant, haustoria

penetrate it. The phloem of the dodder then connects with that of the host. After the connection has been established, the parasite, which is nearly avoided of chlorophyll, lives at the expense of the host plant. If a dodder seedling failed to attach to a host plant, it will die. (Jemal Tola and Taye Tessema 2015)

After attachment to the host plant, new shoots develop from portion of the dodder seedling coiled about the host. The attached seedling has a great capacity of growth. It branches freely and can reattach to another host. The dodder plant grows along with the host plant, often flowering at the same time as the host. (EARO, 2004d) The stems of dodder consist of nodes and inter-nodes, just like green plants. A tiny scale leaf is borne at each node, and a bud within the axil of this leaf can produce a new dodder branch The dodder reattaches itself to hosts of frequent interval. Different dodder species differ in their method of reattaching. In some species, the main stem or its auxiliary branches never twine, but continue to elongate in a straightforward manner. Such species bear tendrils at the nodes but outside the leaf axil. Other species do not bear tendrils and in these species, the tips of the main stem or its lateral branches twine. The twined tendrils or seedlings of dodder contain cells capable of producing new shoot and a profusion of new branches can burst forth from the twined tissue. (Jemal Tola and Taye Tessema 2015).

Spreading of dodder

Distribution of C. campestris was limited to the presence/absence of the host plants such as niger-seed, soybean and garden crops(Jemal Tola and Taye Tessema 2015).Dodder reproduces and spreads mainly by seed. Dodder seeds are heavy and are not adapted for dispersal by wind or water, nor are they specially, attractive to animals that could carry them from one place to another. In agricultural areas, the major means of dispersal of dodder is by of human activities through contaminated seed, animal manure, farm equipment, irrigation water and uncontrolled dodder on fences and along road-sides.

Figure 1:- Mature dodder plant with seeds.

Host range

RezeneFessehaie, 1986 reported as each *Cuscuta* can parasitize many hosts, having a wide physiological tolerance of the metabolism and chemical composition of host species; this is characteristic of parasitic angiosperms. Strains of the same *Cuscuta* species collected from different hosts may differ in their host range. *Cuscuta* has an affinity for nitrofilous host such as legumes and succulents, but will parasitizes a diverse range of angiosperms. Mainly dicotyledons, although grasses and Cyperacae may be minor hosts and onions are susceptible. The suitability of a host such as tomato may vary greatly with its age.

Important crop hosts of *Cuscuta* species include: alfalfa, clover, tomato, carrot, onion, sugar beet, potato, flax, hops, peppermint, safflower, pepper, tobacco, chick pea, Lucerne, asparagus, grape vine, honeydew melon, and several ornamentals. The plant is most important as a pest of Lucerne and other legumes. Grasses sometimes appear to be acting as hosts but are not normally penetrated. Crops commonly parasitized, other than those listed in the table, include asparagus, chickpea, lentil, grape, citrus, melon, Lespedeza and flower crops including chrysanthemum. Not all hosts are consistently attacked, for example tomato is susceptible when young but becomes resistant with age (Gaertner, 1950).

Some comparatively resistant hosts, example sweet potato, and some varieties of potato produce substances which inhibit the action of the cell wall degrading enzymes by which the *Cuscuta*haustoria penetrate the host. *Cuscuta* does not grow well on cereals and other grasses. Penetration is prevented by the anatomy of the grass shoot. In some bean cultivars kills resistance to *C. campestris* is due to a hypersensitive reaction which host and dodder cell at the point where the haustorium penetrates. Once contact is established with the host phloem, *Cuscuta* becomes a powerful sink for metabolites, causing a severe drain on host resources and often completely preventing normal fruit development, as shown by Wolswinkel (1979)in faba bean.

The very destructive effects of *C. campestris*on its host are well illustrated in the work of Shen et al. (2005; 2007) and Lian et al.(2006), with the weed on another invasive species, *Mikaniamicrantha* in China. A range of

physiological effects are described which resulted in a complete prevention of flowering, and almost complete death of the host plant after 70 days.

Figure 2: Dodder, *Cuscuta* species, on tomato

Figure 3: after dodder attaches to a host, its connection to the soil withers.

The Problem of Cuscuta in Ethiopia

It is evident that *Cuscuta* is a new weed in most farmers' fields in which farmers reported seeing it for the first time only 20–25 years ago. In Welega and Gonder *Cuscuta* may have come either from the western lowlands or small pockets of this parasite may have existed for a longtime (EARO, 2004d).

Field observations in Arjo-Bedele areas and Shamboo Fincha district of Welega; Bahr Dar Awraja in Gojam; Addis Zemen, Fogerra Plains and on the Humera road of Gonder region, revealed that serious trouble is caused by *Cuscuta.* Where *Cuscuta* infests noug (*Guizotiaabyssinica*), the most important oil crop in the country, it markedly decreases seed yield and quality. The problems caused by this weed are aggravated by the lack of seed legislation in Ethiopia. Large areas of noug have had to be abandoned every year in the above mentioned areas mainly because of heavy Cuscuta infestation (EARO, 2004d).

Recent survey reports indicated that *Cuscuta* parasitizes young and stumped coffee in the Jima, Melko, Teppi and Bebbeka Coffee State Farms. Noug and linseed are the most known economic crops hosting Cuscuta *campestris* and Cuscuta *epilinum* respectively (EARO, 2004d). The crop mostly affected is noug and this creates problem for the Ethiopian Oilseed and Pulse Crops Export Corporation (EOPEC) who find a large proportion of farmer grown weed sample to be contaminated, resulting in price penalty when the seed is exported (EARO, 2004d).

Cultural Control and Sanitary Measures

Parker and Riches,(1993)reported as Rotation with non-susceptible crops can be helpful. Cereals are virtually immune from attack, and some broad-leaved crops may also be sufficiently resistant, including soybean, kidney bean, squash, cucumber and cotton.There are no known resistant varieties of susceptible crop species, but Mishra et al. (2006) showed variations in response to different varieties of linseed, with damage varying from 7% to 44% in terms of reduced seed yield.

Prevention

According to Dawson et al., 1994use of clean crop seed is vital, and seed should be inspected and cleaned if

necessary, or obtained from a source known to be reliable. Separation of *Cuscuta*seeds from lucerne is quite successfully achieved by equipment comprising felt- or velvet-covered rollers to which the rough seeds of *Cuscuta* stick while the smoother crop seeds pass over. Removal of highly favored hosts such as *Convolvulus arvensis* from around field edges is also recommended.

Biological Control

Julien,(1987)showed that Attempts at biological control of Cuscuta spp. have mainly involved the agromyzid fly Melanagromyzacuscutae and the gall-forming weevils Smicronyx spp. Introduction of M.*cuscutae*, Smicronyxru *fivittatus* and Smicrony *xroridus* from Asia into Barbados for control of Cuscuta *Americana* and C.*indecora* apparently failed, but Smicronyxjun *germanniae* and Smicronyx *tartaricus* have given encouraging results in eastern Europe when introduced from one region to another for control of C.*campestris (*Julien, 1987;Parker and Riches,1993).

Among pathogens, Alternaria *cuscutacidae* is reported to have been used successfully on C.*campestri*sin the former USSR, and a form of Colletotrichumgloeosporioides has been used for many years in China as a mycoherbicide for control of C. *chinensis* and C.*australis on* soyabean (Yulien, 1992; Parker and Riches, 1993).

Therefore biological control is an environmentally sound and effective means of reducing or mitigating pests and pest effects through the use of natural enemies. Of the various biocontrol strategies, biological control of weeds by plant pathogens has gained acceptance as a practical, safe, and environmentally beneficial method applicable to agro ecosystem.

Physical/Mechanical Control

According to Nicol *et al.*, 2007 the young seedlings with rudimentary roots are readily destroyed by shallow tillage before or after crop establishment. Hand-pulling is suitable only for scattered infestations as the infested crop plants have to be removed with the parasite. Scattered infestations can also be controlled by heat, using a hand-held flame gun. More extensive infestations in lucerne are also sometimes treated with overall flaming, as the crop is able to recover. Close mowing is an alternative means of control in lucerne and clovers. Similarly, grazing by sheep can result in significant suppression.

Chemical Control

(Parker and Riches, 1993; Dawson et al., 1994) reported as a range of soil-acting herbicides are effective in preventing the germination and establishment of *C.campestris*.Chlorpropham was one of the first to be used in lucerne and other crops, but short soil persistence meant that it rarely provided suppression for long enough. It has been superseded by other compounds such as propyzamide, chlorthal-dimethyl, trifluralin, pendimethalin, prodiamine, pebulate and ethofumesate, for use variously in lucerne, clovers, lespedeza, sugar beet, onion, chickpea, carrot, tomato, vines, Niger seed. But selectivity is rarely perfect and integration with cultural methods is usually needed. Pendimethalin continues to be the one of the most commonly used herbicides (Mishra et al., 2005), also ethofumesate in sugar beet.

Herbicides for control of established parasites include diquat and paraquat, used for non-selective spot spraying of isolated patches. For more selective control of established *C.campestris*, glyphosate has shown promise in established lucerne, though selectivity is narrow and repeat treatments may be needed (Dawson et al., 1994); also in linseed (Mishra et al., 2005). There are preliminary reports of selective control of *C.campestris*in lucerne by imazaquin (Sarpe et al., 1992), and by imazethapyr and glufosinate (Heap, 1992; Crocker 1987) suggested glyphosate, clopyralid, diquat and metsulfuron for use in amenity areas in Australia. The bleaching herbicides, sulcotrione and mesotrione reduce biomass accumulation, while flurochloridone has only a temporary effect (Weinberg et al., 2003).

Generally chemical control isn't necessary in the home garden and landscape, since you can control dodder for the most part by cultivating seedlings or through hand removal or pruning. Although pelargonic acid (Scythe) is effective, it also kills any plant tissue it contacts; consequently good coverage and careful spraying are important, so desirable plants aren't damaged(EARO, 2004d)Where dodder has been a persistent problem in certain commercial agricultural fields or in landscapes, apply preemergent herbicides (e.g., trifluralin) before dodder seed germinates; where practical, follow up with close mowing, burning, or spot removal of parasitized host plants to control dodder plants that escaped the herbicide application.Usually post emergent herbicides, which you apply directly to the dodder plant to control it, don't selectively control dodder without injuring the host plant and aren't a good choice for controlling established infestations.

IPMProgrammes

Integrated methods involve the all-important use of clean seed; good field hygiene to eradicate scattered infestations before they get out of control; good control of other weeds which might act as reservoirs of infestation; timing of tillage and planting to maximize destruction of parasite seedlings before sowing; and

optimum planting arrangement and growing conditions for a good crop canopy to suppress development of the weed. The classical and bioherbicidal strategies, when applied alone, are not able to suppress this weed. However, integrated pest management (IPM) has gained attention in recent years as a means of reducing losses due to pests, minimizing reliance on chemical pest control, therefore fostering the long-term sustainability of agricultural systems.

Conclusions and Recommendations

The noxious *C. campestris* grows in a wide variety of habitats and causes changes in above ground vegetation as well as in below ground soil nutrients. It is capable of out-competing native and nonnative palatable plants that are important to livestock. Furthermore, the changes in vegetation and soil nutrients could lead to ultimate changes in other trophic levels and alter the function of the ecosystem. Appropriate methods for the management of *C. campestris* are necessary to avoid potential threats to biodiversity and economic losses. The efficient and environment-friendly alternative to other time-consuming, costly, toxic, physical, and chemical methods is the use of biological control through allelopathy, insects and fungal pathogens. The classical and bioherbicidal strategies, when applied alone, are not able to suppress this weed. However, integrated pest management (IPM) has gained attention in recent years as a means of reducing losses due to pests, minimizing reliance on chemical pest control, therefore fostering the long-term sustainability of agricultural systems, and more needs to be done by scientists, agriculturists, and government to work jointly for managing this troublesome weed. The classical and bioherbicidal strategies, when applied alone, are not able to suppress this weed. However, integrated pest management (IPM) has gained attention in recent years as a means of reducing losses due to pests, minimizing reliance on chemical pest control, therefore fostering the long-term sustainability of agricultural systems.

Herbicides and mechanical control (digging, cutting, ploughing or burning) are the most adequate and most frequently chosen forms of control of this noxious species, as well as some other. However, eradication of noxious weeds by herbicide treatments on non-agricultural areas is too costly, while concern for preserving the surrounding vegetation does not provide much opportunity for herbicide treatments. Besides, chemical control is not acceptable on sites close to water sources, and in gardens and yards around housing facilities.

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