

The Major Sweet Potato Weevils; Management and Control: A Review

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ABSTRACT

Sweet potato is an important food crop, grown commonly in tropical and subtropical regions, but production has been subjected to less research worldwide, compared to the major staple crops. Sweet potato weevils are the major destructive pest causing drastic yield decline and resulting in a decrease in millions of dollar annually. A wide range of management strategies in controlling sweet potato weevils includes; cultural method, chemical method, biological method, Sterile Insect Technique, soil management, Sterile Insect Release, pheromone traps, Host Plant Resistance and Integrated Pest Management. However, the chemical method is limited by larvae internal feeding, whilst the biological approach has been constraints to some point. The pheromone method has enhanced for monitoring of sweet potato weevils, but adapting to integrated pest management is most highly effective and environmentally safe to growers. This paper reviews the factors that contribute to the infestation of weevils, mode of infestation, and various control management strategies towards decreasing the infestation of weevils in the plantation of sweet potato.

Keywords: Sweet potato; Weevil; Cultural control; Biological control; Pheromone control; Integrated Pest Management (IPM); Yield loss

INTRODUCTION

Sweet potato belongs to Convolvulaceae family with more than a hundred developing countries, known to cultivate sweet potato and are ranked the 5th most essential foodstuff in over 50 of those countries [1] and globally, 7th amongst the entire food production [2], but has lesser experimental work than other staples such as potato (*Solanum tuberosum*) and wheat (*Triticum aestivum*). Sweet potato as an economic value crop, the vital staple food, grown in over one hundred different countries, its main root and tuber grown in the tropical and subtropical regions of the world in the developing world [3]. Although sweet potato is known to originate from South and Central America, Asia is known to be the world producer, particularly China carrying the highest yield of the sweet potato nationwide [4].

Due to sweet potato superior qualities, it has given great potential for reducing hunger, specifically, in low-income households in developing countries [5]. Different sweet potato varieties have nutritionally beneficial compounds [6]. Sweet potato provides a source of calories, vitamins, dietary fiber, and potassium, especially in rural areas [7,8]. Currently, researchers have found that sweet potato contains anti-oxidative properties [9], making sweet potato increasing the importance in developed countries, but in less developed areas, hower, attention is towards raising the nutritional value of the product [10,11]. Carotenoids in sweet potato have helped in avoiding nutritional deficiency in children [7,12,13].

Despite the economic demand for sweet potato, roots are highly perishable, if not well treated and adequately stored, and are mainly threatened by insect pests that can lead to severe economic loss. By far, the absolute limit of sweet potato yield worldwide is damage of the plant caused by weevils [14,15]. Sweet potato weevils are widely spread throughout the tropical regions of the world, but the methods of control are the significant problem faced by growers in most countries producing sweet potato. Cylas formicarius (Fabricius), Euscepes postfasciatus (Fairmaire), Cylas brunneus (Fabricius) and Cylas puncticollis (Boheman), are the 4 key species of sweet potato weevils that cause the most enormous damage to sweet potato cultivation area [16,17]. This review aimed to summarize the infestation of sweet potato weevils, mode of infestation of weevils on sweet potato and various control strategies towards decreasing infestation of weevils in sweet potato plantation, hence increasing vield.

MAJOR SWEET POTATO WEEVILS; MODE OF INFESTATION

Generally, weevils cause severe feeding destruction to sweet potato roots, vines, stems and leaves through their life cycle, beginning from the egg stage to adult stage. After mating, females lay eggs, create tunnels in holes inside the roots below the surface, the

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laid eggs are covered with dark colour excrement [18], making it unattractive for a market.

Hatching generally occurs a week after oviposition. Several tunnels are constructed within the root and feeding within the circle by the hatched larvae [19]. The larvae then fill tubes inside sweet potatoes with excrement. Continuous feeding by the larvae, result in unpleasant smells on the sweet potato as well as terpene odor, making it unacceptable for consumption by humans or animals. The occurrence of terpenoid decreases the market value and quality roots [20]. Physically the appearance of root tubers turns out to be soft, dark in color and filled with cavities caused by mining of larvae in the sweet potato, leading to the main damage cause to sweet potato.

Due to destructive action by weevils, United States quarantine actions are tough on growers, since it has a significant economic effect on the whole crop, and this has made farmers abandoned production of sweet potato [21].

Clearly, after a heavy infestation of weevils, the vine becomes yellowish, and this mark as symptoms of weevil infestation [22–24] (Figure 1). Considering the significance of soil cover, weevils of sweet potato is a critical obstacle in arid seasons [25,26]. At hand, there are four life cycle stages that weevils undergo [3] and their life span for each stage is much dependent on the climate and the temperature of the location.

Several research works have determined that the increase in temperature, the higher the rate of population of insect growth, and the threat and severances of the insect occurrence [27,28]. At lower elevations of less than 2000 m above sea level, damage to the crop tends to be more [26,29]. In the drier period, the higher the temperature, the higher the frequency, may be the possible influence on sweet potato weevils [26].

The infestation of sweet potato weevils depends mostly on cracks in dry soil to get to the firm root since weevils cannot dig into the ground under buried soil. Cracks in the soil can also be developed when there is stress from soil moisture and development of roots close to the soil surface and then subjecting roots to sweet potato weevils.

The 4 sweet potato weevils infest sweet potato equally in the field and at storage, causing extensive losses of up to 60% to 100% [30]. Rough weevil, striped weevils, and peloropus weevils are other weevil pests of sweet potato [16,31,32]. The different *Cylas* spp are located in distinct geographic regions, but their mode of action and damage symptoms to sweet potato plant are similar (Table 1) [33-45].



Figure 1: Weevil feeding damage on root, stem, vine and leaves of sweet potato.

CAUSES OF INFESTATION OF SWEET POTATO WEEVILS

Stage of stem cutting

In older parts of vines, female weevils lay eggs, especially when the storage roots are absent. Cuttings that are younger are not often infested with sweet potato weevils. Asian Vegetable Research and Development Center recorded that high intensification of weevils in vines is caused by the rise in vine age. Vines can be free from weevil infestation by dipping into a solution of insecticides [46].

Altitude and season

Location of altitude and season of the planting of sweet potato has a connection in weevil infestation. Numerous research studies stated that an increase in temperature may give a higher growth rate of the population of insects and severity of occurrences [27,47]. At planting period from August-November, the number of weevil infestation increase at a rate of 87% as compared to the period of planting from June-July, where the infestation of weevil rate at 10.9% in India [48]. In India, research conducted indicated that damage on tubers increased at a higher rate of 71% during the season of summer from February to May as compared to the wet season at a rate of 45% from June to September [49].

At an altitude, a research conducted in Kerala shows that damages on tubers by weevil infestation was observed to be lower of up to 22% at lowland level whiles at upland level, weevil infestation damage on tuber increase at a rate of 4%-50% [49]. Also in Uganda, studies reported that there is an increase in a number of weevil infestation at a rate of 77% at lowland above sea level at 1814 m compared to the amount of weevil infestation at altitude, higher at a rate of 23% up to 1992-2438 m above sea level [26].

The weevil infestation may also be affected by planting method, cultivar planted as well as the level of sanitation. The infestation of weevils can decrease by the use of cultivars with good resistance against weevils, proper harvesting time and location for planting since observation has shown that the destruction of incidence caused by weevils of sweet potato was detected to be lower during the rainy season, because there is no crack to access the roots as compared to the dry season [50].

Physical characteristics of sweet potato

Physical qualities including shape, thickness, and length of neck and colour of the skin of sweet potato influence weevil infestation. Round and oval shape tubers of sweet potato were also infested by weevil more severely as compared to longer ones. Besides, brown and white colored cultivars are more susceptible to weevil infestation as compared to red and pink cultivars of sweet potato [51].

Early maturing of 90-120 days and deep-rooted cultivars are less prone to infestation as compared to the late maturing of more than 180 days and shallow-rooted, since 95% or more of female weevil's oviposition takes place in vines at the first 35 cm [52].

CONTROL AND MANAGEMENT STRATEGIES OF SWEET POTATO WEEVILS

Intercropping

Intercropping sweet potato with yam, cowpea, maize, ginger,

Table1: The life cycle and mode of infestation of weevils.		
Species of sweet potato weevils	Life cycle and mode of infestation	
Cylas formicarius (Coleoptera: Brentidae)	Origin: Malaysia, southwest Pacific [33] . Affect both tropical and subtropical sweet potato plantation [16].	
	Usually, the pest is tiny with a red thorax and blue-black abdomen.	
	It causes damage to the majority of pre-harvest sweet potato plant [34,35].	
	The insect can tolerate low temperature, especially during the winter to some extent, even it is a tropical and subtropical insect [36].	
	Weevils attack sweet potato crop at a higher altitude of 1600 m about sea level [37].	
	Life cycle:	
	Egg stage (5-14 days) 🛶 larvae (10-35 days) pupae (7-28 days) adult (20-94 days) [17].	
	oviposition stages	
	Female lay one egg per time and cover it with the faecal mass to hide the eggs.	
	(5-90 eggs can be laid by active females, 33 days of their life span. [37].	
	Adults Female lay eggs between 50 and 250 [22,56]	
	For susceptibility adult and larvae are easy to target by natural enemies: including predators, parasitoids, and pathogens	
	[38]	
	Fungal pathogens: Metarhizium brunneum and Beauveria bassiana also attack Cylas formicarius [40].	
	Origin: East Africa	
	Cylas brunneus showed a background characteristic as Cylas Formicarius [31].	
	Mohammed explained more detail on the biology of Cylas puncticollis [41].	
	Cylas brunneus developmental period is slightly longer, but other biological information is sometimes conflicting [42].	
Cylas puncticollis and Cylas brunneus	On physical differentiation, <i>Cylas puncticollis</i> are clearly to differentiate as the adult are black in colour and prominent, but adult <i>Cylas brunneus</i> are tiny in size and unequal in colour.	
	Larvae	
	Feeds inside the root and stem, deposit debris in tubes, causing malformation and thickening Adult	
	Feeds on the outer surface of leaves and roots, causing irregular to circular punctures.	
	Cylas brunneus injuries are found near the crown of roots exposed to the surface whiles Cylas puncticollis, leaf-feeding by the adult, reduces the photosynthesis activity of the plant.	
Euscepes postfasciatus	Origin: Caribbean South Pacific, Japan , South and Central America [22,38,43].	
	The life cycle is much similar to that of Cylas formicarius, even though it has not been documented to fly [22,23].	
	Larvae stage	
	Bore into the vine or the root leaving excrement in tunnels.	
	Adult stage	
	Feeding in groups, fully into the storage root, causing extensive and numerous holes, and slight punctures above the whole surface [22].	
	Ecology and biology of <i>Euscepes postfasciatus</i> research were examined as part of the destruction work by the Japanese [39,44,45].	

and rice decreases the occurrence of weevils. There was a drastic decrease in *Cylas formicarius* species in India where the sweet potato was intercropped with cowpea, taro or rice [37]. In India, a study revealed several agronomic importance such as weevil suppression and soil moisture conservation, intercropping with different kinds of crop species [53]. In Taiwan, different crops of about 103 were tested, the best result was recorded from intercropping with coriander (*Coriandrum sativum L.*) [54].

Effective cultural practices

Cultural practices are aimed at preventing infestation of weevil. Weevils can feed on sweet potato and weeds in the same plant family, thereby making cultural controls as a potentially useful control method in sweet potato production [55,56]. Some cultural practices in sweet potato include the elimination of dead crops, separation of un-infested planting material, elimination of unwanted plant and alternative wild host as well as rotation of crops in order to set up a free pest material and avoiding frequent build-up in new crops [37,57]. Some cultural practices in controlling of sweet potato weevils are shown in Table 2 [58-65].

Soil management

Management of soil helps to avoid cracks in the soil, which aimed to minimize crop destruction as much as populations are existence. Weevils of sweet potato cannot tunnel into the soil, but instead, they like cracked or dry soil which gives them the right entry to the roots.

Mounding soil or mulching are frequently used in preventing soil cracking [66]. Plastic materials, as well as straw ensure a barrier for the development of weevils into the soil [57,67]. Mulching with elephant grass at a level between 1 and 5 tonnes per hectare decrease the infestation of weevil as well as help to improve the yield of storage root [68].

STERILE INSECT TECHNIQUE (SIT)

The use of SIT is an important approach to decrease the population of weevil in sweet potato production. SIT means irradiation of weevil with gamma rays, and are used for tubers that are put in storage for a prolonged period of time or export purposes. SIT has mostly used for the sterilization of weevils [69,70] and eradication

	Table 2: Sweet potato cultural practices.
	Cultural practices methods
Sanitation	Removal of alternative hosts and wild plants [58]. Crop rotation with other crops is effective against sweet potato weevils [59]. Burying or burning of infested roots or feeding to livestock [54].
Mulching	Prevention of cracks and ensure a favorable environment for natural enemies. Mulching with black plastic or straw of rice decrease the infestation by sweet potato weevils in the root zone [60].
Early harvesting	Harvesting crop 14 days earlier decrease the yield loss [61]. Sprout Vines left on the field provides food for weevils [62]. Timely harvesting. Soil should be hill up around the leftover roots to avoid weevils from getting access to cracks [54].
Flooding	Flooding of the field before planting prevents infestation of weevils [63]. 48 hours or more flooding of the field destroys larvae currently in roots that have been left on the field [64]. Repeated flooding of fields of sweet potato might lower the instant source of weevil on the field [64].
Use of clean planting material	Softer planting materials are less likely to be infested by sweet potato weevils [65]. The use of non-infested planting materials of sweet sweet significantly controls weevil infestation in the field and at storage.

programs where there is a release of irradiated weevils into the environment [71]. In Japan, Okinawa Prefecture programs for eradication for sweet potato weevil species *Euscepes postfasciatus* [39,45,71].

The central importance of the releasing sterile male helps populations decrease, together with other methods, helps to make the location a pest free. Sterile males during mating with females will not result in progeny, which then produce in total decreased in population in the next generation [72]. For example, radiations cause adverse effects on somatic cells and lower insect viability, which affects fertility when there is an increase in absorption. [73]. Again, radiation destroys the midgut epithelium, which disturbs the process for insect's nutrition [74]. Due to the long generation, time for eradication program is most expected to take place at a more prolonged period, and difficulties occurred throughout the mass rearing [45].

STERILE INSECT RELEASE (SIR)

SIR is one of the essential methods in controlling sweet potato weevil infestation. In 2001, some researchers performed long-term research to look into the effectiveness of the SIR technique to clear and destroy weevil species, *Cylas formicarius* in the field [75].

In 1994 and 1995, weevils were irradiated with 80 Gy by some researchers; they stained with fluorescent dyes, free them in a relief zone. In 1994 to 1995, root and pheromone traps were used to monitor the weevils, and in 1996, the sterile weevil-free effect was rechecked. But in 1995, the number of the unmarked results reviewed that weevils captured in the free zone was lessened to virtually nothing whilst in 1996, in both pheromone and root traps no living weevils were obtained at the time of rechecked in the release zone. All results obtained in various years indicated that the SIR technique is a beneficial method in preventing infestation of weevil [76].

In 2008, another research scientist performed a trial to find out the effect of irradiation 200 Gy dosage on the mating capacity in sweet potato weevils, *Cylas formicarius elegantulus*, main aimed to compare various characteristics such as performance on mating,longevity

and mating effectiveness with the control male. At the end of the trial, the existence of male weevils was reduced once it was being irradiated with gamma rays [71].

Pheromone control

Field and laboratory observations show that there are perhaps sex pheromones for *Cylas puncticollis* and *Cylas formicarius*. In rearing rooms, the behavior of gregarious clumping was known, and the definite attraction of males to the females [77] whilst in the field, males, are mostly set up under foliage seeking for females. Tests at the laboratory have pointed out that, males are attracted to females. The probability of using unmated females and virgin as baits for males in traps was examined in Kenya [78].

In a timely manner, a pheromone has been explicitly improved for examining weevil species, *Cylas formicarius* so that control methods can be carried out [38,79].

The pheromone (Z)-3-dodecen-1-ol (E)-2-butenoate has shown to be more effective mating for the prevention of *Cylas formicarius* [80,81], mainly for trapping both sexes of weevils. With a dose of 100 mg of sex pheromone, 60.88% weevils were attracted. During different parts of the day, the weevil trap varies significantly.

Traps that are fixed close to the ground trapped more males compared to those set above the ground [81], several kinds of traps for preventing weevils are sticky, a plastic funnel, water, and light pheromone.

Japan has developed an insecticides or pheromone supply system in the way of low volume formulation insecticide and pheromone permeated into a blue ball of diameter 2 mm where male weevils would attempt to mate by coming into contact with the pheromone or insecticides [82]. The combination of *B. bassiana* and *B. pheromone* attracts male weevils [56,83,84]

Host plant resistance

The selection of different cultivars over the years by the farmer was based on a higher resistance to weevils, for instance, the use of deeprooted cultivars can make the roots less accessible for oviposition

female weevils [37,85,86].

Orange-fleshed varieties are exposed to superior resistance [87]. Dry matter content influences the resistance of weevils [88], with an increase in dry matter content, cultivars tend to reduce susceptibility [89]. Landrace varieties are generally acceptable to local consumers since they have traits and have good adaptability to the environment [90-92].

Varieties with resistance to weevils are as a result of hydroxycinnamic acid esters on the exterior and the root latex, decreases weevil's nourishment and oviposition. Hydroxycinnamic acid esters now will be implemented as a character in breeding approaches, which were conducted in recent research work in Africa [93]. This research work gives other chances for sweet potato location where the collection of germplasm that exists can be examined for similar compounds that provide resistance to the importance of weevil species.

Researchers in different countries have expressed views in using *Bacillus thuringiensis* in production of sweet potato. For instance, in sub-Saharan agriculture, the application of transgenic *Bacillus thuringiensis* sweet potato is considered as an attractive alternative to lowering the mobility of conventional breeding for the resistance of host-plant and other pest management selection in which few thought about it to be more costly for growers to practice [94,95].

Currently, Transgenic sweet potato cultivars expressing Cry proteins of *Bacillus thuringiensis* are in progress [96]. *Bacillus thuringiensis* protein expression in sweet potato has been introduced in Cuba [97], China [98] and India [99].

INTEGRATED PEST MANAGEMENT (IPM)

IPM managements are used in several approaches to control a large number of damage pest including; cultural practices such as field sanitation, crop rotation, site selection, correct planting season, plant spacing, companion cropping and soil water management, biological control such as natural enemies which feeds and protect crops, mechanical control such as hand picking and screening and chemical control, but most farmers practice is limited [100], because of their lack of knowledge on the biology of the pest.

IPM approach programs such as pheromones trap, Entomopathogenic fungi, cultural method and resistant cultivars has improved the yield in Cuba from 6 tonnes per hectare to 15 tonnes per hectare [101]. Also, the IPM program implemented in Taiwan has helped the local farmers; these applied methods include crop rotation, alternate host removal, continuous pheromones trap and mulching [102]. The IPM implementation depends on proper dissemination of information, likewise training of farmer [103]. Strategies used in IPM has gain approval from growers, which helped growers to raise funds as soon as they are related to cultivars or techniques that can increase profit [104].

Chemical control

The use of insecticides in control of pest in sweet potato are usually too expensive or inaccessible to growers [90], even though insecticides are generally used in controlling sweet potato weevil in developed countries [16,37] but less among poor farmers.

Parathion and chlorpyrifos insecticides have shown greater toxicity and higher effectiveness in overcoming weevil infestation on sweet potato [80]. In Ethiopia, screening trials for both Deltamethrin and

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pirimiphos methyl insecticidal showed reasonable control of sweet potato pests, especially when an application is made 3 months after planting [78]. A mixture of vine dipping of 0.05% monocrotophos and three sprays of foliar with endosulfan of 0.05% showed entirely useful as compared to the application of phorate granules at basal [105].

Time of applying insecticide can be range from one factor to systematic factor applications [37,106]. But for certain chemicals also, persistent toxicity is a problem through a residual observable for 10 months, whereas others, residual at harvest had no detection.

Planting vines that are dipped into insecticides are relatively at a low cost; the most commonly used insecticides by farmers. But most farmers usually lack basic knowledge on personal use of protective clothing and dangers of insecticides to the health of human leading to the potential danger to smallholder farmers [90]. Recently, some researchers reported spinosad and azadirachtin as low-risk insecticides to be active against *Cylas formicarius* in a trial work at the laboratory, but then their activeness was not examined in the field [107].

Drenching of Soil at 50 and 80; 60 and 90; and 50, 65 and 80 days after planting were similarly effective in destroying the incidence and intensity of weevil damage [108]. Amongst the single soil drenching, the 65th day application was assessed to be the most effective against the weevil. Endosulfan, fenthion, and fenitrothion each at 0.05% as applied by means of drench soil at 50 and 80 days after planting were efficient, and their damages in tubers during harvesting were lesser compared to the noticeable level [109].

Biological method

Different classes of insect have been identified as predators of Cylas spp [16,22,33], in different geographical regions, but the cost and technical know-how associated with their biological controls remains a challenge in the small scale farming system (Table 3) [110-121].

CONCLUSION AND RECOMMENDATION

Sweet potato is one of the fastest and main growing crops in many countries, but due to the infestation of weevils, there is drastic loss in yield, especially in less developed countries on poor farming families. It is a clear indication from the review that sweet potato weevils are major constraints in production all over the world. But occurrence differs in different locations depending on the type of cultivar used and management methods adopted.

Weevils are not the same in different locations. Therefore control strategies are difficult by growers leading to low productivity. In order to decrease the impact of weevil's infestation we have to develop an integrated pest management approach, such as cultural methods, based on the manipulation of weevil's behavior, effectiveness pheromone trap makes it a significant approach within integrated pest management with the expectation of controlling sweet potato weevil, host plant resistance, biological control, time and appropriate rate of chemical application, natural enemies, reduction of insecticides impact on the environment and weevil-resistance varieties. Henceforth, the evolvement of integrated pest management strategies is important compared to a single management strategy.

Research teams now researching on transgenic weevil resistance can release long-awaited transgenic sweet potato with foreign genes

Table 3: Biological methods for control of sweet potato weevils.

	Biological control methods
Parasitoid	In South-west islands of Japan, new species of Bracon yasudai and braconid were found and reported with parasitism of
	20–40% of Euscepes postfasciatus in the field [110].
	In Philippines and USA, new species of <i>Bracon</i> act as sporadic parasitoids of <i>Cylas formicarius</i> , where the genus is
	identified as parasitizing a collection of species [110].
	Palaniswami and Rajamma reported the braconids Rhaconotus spp. and Bracon spp. an unidentified hymenopterous
	parasitoid on the larvae of sweet potato weevil [111].
	Euderus purpureas, a eulophidae was parasitizing on Cylas formicarius in Southern Florida [112]. However, the success of all
	these parasitoids at field conditions is uncertain since they are recorded in very insufficient numbers.
	The ants are a significant factor in controlling weevils of sweet potato. Similarly, in the system of PNG, where there was a
	cultivation of taro on hills of ants [113], but now adapted for practice in the production of sweet potato.
	Both Tetramorium guineense and eidole megacephala are the significant ants, which provided adequate control of Cylas
Predators	formicarius, a common inhabitant in banana plantations.
	In Cuba, ants were transported from their natural zone to the field with banana leaves rolled as "temporary nests," aimed
	to target weevils and new pests.
	Areas with a buildup of ant colonies thirty days after planting has decreased infestation of weevil from 3% to 5% [101].
	EPN has advantageous relations with sweet potato within the roots for the prevention of weevils [114], but relatively a high
	cost in introducing EPN method into smallholder farming systems [115].
Entomopathogenic	Heterorhabditis found among different species was indicated to be most effective and pathogenic than Steinernematids
Nematodes	[116] Research on Heterophabditis indica and S karii in Kenya resulted in a high death rate of larvae and adults [117]
	Steinemeng carbocation is at the laboratory but in
	the field, a decreased of 40%-60% damage on weevils [118].
Entomopathogenic Fungi	Surving of B basising solution at a concentration of 1 by 104 conidia mL 4 rootstock formation and broadcasting of
	sophaying of <i>D</i> , basiland solution at a concentration of 1, Nove Control and p. 10050000 (offsatively [110]
	Ching has been recommend as next of the multiple commonies that are into more production of Recurring having and
	Clinia has been recognized as part of the multiple companies that are into mass production of <i>Deawena bassiana</i> and Materialism gristerities which are well suited in hot and humid conditions for use grained a range of posts [120], suprantly
	Metamizium ansopiue, which are wensulted in the LISA as biometricities (121)
	are registered in the OSA as biopesticides [121].
	Entemporth granic fungione species 20 days after planting during son mound, decreases 40% of adult weevil [121].
	Entomopathogenic lungi are significant against <i>Cylas puncticolis</i> , since it causes a reduction in feeding ability, fecundity
	and egg viability [40].

that are resistant to the weevil's infestation.

Extension officers should educate growers on sweet potato on the importance of using healthy planting materials and demonstrations approach should be performed on farms for growers to be skilled in controlling weevils at the early stage and variety screening by means of identifying traits that are best for combating the previous pests.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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