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Review

Pests of selected bioenergy crops

Lucia Iľková*, Ľubica Šütöová
National agricultural and food center, Agroecology Research Institute Michalovce, Slovak Republic

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The question of energy independence is crucial for many countries in the developed world these days. In addition to solar and wind energy, agriculture and plant production are sources of renewable energy. Crops can be grown for the production of biomass for direct combustion, biofuels, and bio-ethanol. In addition to these benefits, lignocellulosic plants have a huge potential for wide application in industry, construction, paper, automotive, and pharmaceutical industries. However, the yield of products from energy crops depends on many environmental factors, and one of them is their pests. In this article, we reviewed selected energy crops (*Amaranthus* spp., *Cannabis sativa* (L.), *Panicum virgatum* L. and *Sida hermaphrodita* (L.) Rusby) and their most important pests. Summarizing the literature we discovered that the most prevalent pests are different types of insects as well as viral and fungal pathogens.

Keywords: energy crop, bioenergy crop, pests, biomass

1 Introduction

Today's world of technology needs more and more energy for its operation. The social, financial, and political situation pushes for ever greater mining and processing of fossil resources. The use of fuels such as oil, natural gas, or coal causes an excessive burden on the environment by accumulating carbon dioxide in the atmosphere. Increasing demands and prices, however, have opened the possibilities of using renewable resources. Among them, research has focused on agriculture and energy crops. Biomass has started to be used for bioenergy, biofuels, and biorenewable materials. In addition to direct use, growing energy crops has other advantages. Degraded cultivated soils or pastures can be used for their cultivation. They also improve the environmental stability of the country, including improving the quality of water and soil (Tolbert et al., 1997). When growing them, it is not necessary to use a lot of herbicides and pesticides, so they do not pollute the environment. Unlike fossil fuels, energy crops use CO_2 and produce oxygen (Skoufogianni et al., 2019).

Like all plants, energy crops also have their pests. Although their cultivation is not as demanding as cultivated crops, it is necessary to know the pests to protect the plants. In this review, we provide an overview of 4 energy crops *Amaranthus* spp., *Cannabis sativa* (L.), *Panicum virgatum* (L.) and *Sida hermaphrodita* (L.) Rusby) with their most important pests.

Pests of selected bioenergy crops

Panicum virgatum (L.)

Panicum virgatum (Poaceae) also known as switchgrass is a perennial grass that is native to the United States and flourishes in prairie soils, marshes, open woods and sometimes can be found along roadsides (Rouquette Jr et al., 2020). The grass is popular for its heterogeneous germplasm and the fact that is uses C_4 carbon fixation which is beneficial mainly when it comes to harsh weather conditions such as drought and exceedingly elevated temperatures (Tóth, 2018). *Panicum virgatum* has evolved into becoming a model energy crop for ethanol and electricity production in America. However, there are several projects in which switchgrass is being probed as an original lignocellulosic C_4 biomass crop for adaptation in European conditions and the use for energy and fiber applications (Elbersen et al., 1998).

***Corresponding Author:** Lucia Iľková, National agricultural and food center – Agroecology Research Institute, Špitálska 12, 071 01, Michalovce, Slovak Republic; e-mail: lucia.ilkova@nppc.sk
ORCID: https://orcid.org/0000-0002-3491-0147

Like any other crop, *P. virgatum* has its own pests that can harm or even destroy the plant. The most common pest known to attack switchgrass is the Switchgrass mosaic virus (SwMV). The mosaic virus (Tymoviridae) is a positive-sense single-stranded RNA virus and is normally transmitted to grasses by leafhoppers(Agindotan et al., 2013). The SwMV infection creates straight white, creamy, or yellowish lines and dots in leaves that run parallel all the way to the veins. The virus is distributed through the Southern part of the USA, and it can also be identified in Australia, precisely in New South Wales (Zambrano et al., 2013; Malmstrom et al., 2022).

Haimbachia albescens (Crambidae) also referred to as the silvered haimbachia moth can be observed in North America and the larvae feed on switchgrass. *Blastobasis repartella* (Blastobasidae) is also a moth, it is found in North America. The larvae perforate the proaxis, basal nodes, and internodes of above-ground stems of *P. virgatum* resulting in damaged or decomposing plant matter (Prasifka et al., 2011).

Bipolaris victoriae (Victoria blight of oats) is one of the major pests of switchgrass as well. It is a fungal plant pathogen part of the family Pleosporaceae. The fungus causes disease in grasses that are grown as fodder for human utilization or as biofuel. *Bipolaris victoriae* is seed transmitted between regions and is known for victorin, a toxin produced by the fungus itself, which causes photorespiratory stress inducing premature senescence in the tainted plants. The fungus was detected in North America, South America, Africa, Asia, Oceania, and Europe (Denmark, Germany, Ireland, Netherlands, Switzerland, United Kingdom, and Scotland). Some examples of other but minor pests of *Panicum virgatum* are *Alternaria alternata*, Barley virus G, *Sclerotinia homoeocarpa*, *Papaipema nebris* and *Spodoptera frugiperda* and *Puccinia emaculata* (CABI, 2016)

***Amaranthus* (*Amaranthus* spp.)**

Amaranthus (Amaranthaceae) also referred to as pigweeds is spread all over the world (North America, Europe, Africa, Asia, New Zealand). It is a genus comprised of annual and short-lived perennial plants and shrubs. Several species are cultivated as grain crops, leaf vegetables, and ornamental plants (Brenner et al., 2000). *Amaranthus* is known for its rave nutritional features, in other words, the leaves provide an abundant source of calcium, iron, vitamins A, B, and C while, and grains are ample in dietary fiber, minerals, and amino acids. Furthermore, amaranth is utilized as a forage crop. Pigweeds are C_4 plants meaning they can photosynthesize at higher temperatures in concert with a greater water use proficiency in comparison to C_3 plants. Besides the already mentioned, amaranth serves as a potential bioenergy crop (Assad et al., 2017; Seni, 2018). Amaranths lignocellulose has the capacity to be employed as raw material for bioethanol production due to high yields of biomass per hectare. Amaranth plants require minimal irrigation and can endure severe environmental conditions (Baturaygil et al., 2021). Nevertheless, amaranth cultivation is sometimes impacted by infestations of diverse pests that feed on distinct parts of the plant or cause certain diseases.

The Amaranth stem weevils *Hypolixus truncatulus* and *Hypolixus nubilosus* are polyphagous beetles that belong to the superfamily Curculionidae. *H. truncatulus* was identified in India, Mexico, Pakistan, and Thailand while *H. nubilosus* was observed in Egypt and Kenya (Rajeshkanna & Mikunthan, 2017; Seni, 2018). The adults of both beetles cause damage by feeding on the leaves, creating abrasions on the stem, and feeding on the inner sections of the stem. Larvae form winding tunnels inside the stems resulting in reduced vitality and robustness of the plan. The effect of the stem weevils can be amplified by their capability to spread *Fusarium* species. *Fusarium* is a genus of filamentous fungi that can cause stem and branch deterioration (Aragón-García et al., 2011).

Liriomyza huidobrensis (Agromyzidae) or the serpentine leaf miner is a small fly. It is a highly polyphagous pest that is distributed through North America, South America, Africa, Asia, and Europe. *L. huidobrensis* produces sinuous veins in the leaves that are typically white with irrigated black and dried brown patches. By feeding on the leaves larvae can generate leaf wilt (Alves et al., 2014; Ahya & Liyana, 2018).

Circulifer tenellus (Cicadellidae) sometimes familiar as Neoaliturus tenellus or as the beet leaf hopper This leaf hopper is present in America, Africa, Asia as well as Europe. The damage caused by *C. tenellus* can be direct or indirect. Direct damage is prompted by feeding on leaves but this causes subsidiary harm. On the other hand, indirect damage, triggered by transmitting pathogens such as viruses and phytoplasmas can cause serious detriment. The beet leafhopper is the only insect vector of the beet curly top virus (BCTV) (Rondon & Murphy, 2016). The virus is a pathogenic plant virus that consists of single-stranded DNA. BCTV is transmitted to nymphs of *C. tenellus* and after the feeding, the plants get infected with the virus. This virus affects numerous plants pigweeds being one of them. BCTV causes leaf curling, vein swelling, necrosis and hyperplasia of the phloem, and stunting (Munyaneza & Upton, 2005). Phytoplasmas are phloem bound tiny pleomorphic bacteria, transmitted through the saliva of infected insect vectors. These parasites cause stunting, little leaf, phyllody, virescence and floral malformation (Kumari et al., 2019).

Myzus persicae (Hemiptera) also known under the name green peach aphid is a tiny aphid and is a grievous pest of amaranth distributed all round the world except in environments with extreme temperatures or moisture (Walgenbach, 2018). The nymphs and adults of this aphid cause harm by sucking plant sap which effectuates yellowing and drying of leaves. Also, growth malformation, leaf curling and drying is a result of the aphids' presence. The aphids produce a huge amount of honeydew which is a medium where mold grows. This mold then causes the leaves to blacken leading to reduced photosynthetic activity. Other pests of the *Amaranthus* species that are not so prevalent include, *Spoladea recurvalis*, *Pseudomonas syringae* pv. *actinidiae*, *Helicoverpa zea*, *Diabrotica virgifera zeae* and *Spodoptera praefica* (Seni, 2018).

Sida hermaphrodita (L.) Rusby

Sida hermaphrodita is a perennial herb within the Malvaceae family and its other recurrent names are Virginia mallow and Virginia fanpetals. This plant is native to North America where it was first observed close to wetlands, floodplains, and rivers (Borkowska & Molas, 2012). *S. hermaphrodita* has been studied in Eastern Europe since 1980 as a fodder and energy crop however there is still an insufficient amount of data in the English language. Cultivation of this fodder crop takes place in European countries which include Poland, Germany, Austria, Hungary, and Lithuania (Remlein-Starosta et al., 2016). Based on studies this herb is an alternative crop that can be utilized for bioenergy production as its yields only multiply through the course of five years after initiation. Virginia mallow can be applied to fabricate biomass for direct combustion or biomass to produce biogas (Cumplido-Marin et al., 2020).

Sida hermaphrodita is susceptible to certain pests but it must be taken into consideration that none of the following pests have been confirmed with and are reckoned only as potential pests of this plant. *Coreus marginatus* (Coreidae), *Lygus bugs* (Miridae) and lastly *Aphis fabae* (Aphididae) are the possible insect pests of Virgina mallow (Pszczółkowska et al., 2012). Two probable diseases endangering *S. hermaphrodita* are caused by *Fusarium* and *Botrytis cinerea* (Pszczółkowska et al., 2012). Periconea sidae is a fungus that has been identified on the herb in Europe sometime in 2015. *Sclerotinia sclerotiorum* is however the most profound disease of *S. hermaphrodita*. The pathogenic fungus was found in more than 20% of diseased plants. It infects stems causing them to shrink and is responsible for overall yield losses (Bedlan & Plenk, 2016; Cumplido-Marin et al., 2020).

Cannabis sativa (L.)

Cannabis sativa (L.) (Cannabaceae) is one of the oldest non-food crops in the world. Hemp has been cultivated since the 16th century in Europe for several end products such as seeds, natural fibers, and cannabinoids(Schultes, 1970). It is used for the treatment of aches, diabetes, and several diseases associated with deteriorated mental health. Hemp oil and seeds can be used as food or as a component of cosmetics (Lancaricova et al., 2021). In addition, it is cropped for biomass due to the high energy yield during combustion (Kraszkiewicz et al., 2019). This is the reason why interest in its cultivation has increased again in several EU countries (Germany, France, etc.) (Van der Werf, 1994). Growing hemp is not difficult. Although the plants are very sensitive to the structure of the soil and the presence of an optimal amount of water, they require almost no biocides, they suppress the growth of weeds in their surroundings and the use of fertilizers is not necessary (Struik et al., 2000).

Despite the widespread opinion that hemp has few pests (Porvaz et al., 2011), up to 10% of crops are lost due to diseases or damage annually. The plant is attacked by viruses, microorganisms, fungi, parasitic fungi, and insects. Among the most important pests is the gray mold *Botrytis cinerea*. It affects the flowering tops, especially of drug cultivars, mycelia, and stems. The plants wither, become soft, and even rot. The disease is transmitted locally from neighboring plants, in a temperate zone with high humidity. Under these favorable conditions, it can reach epidemic levels and completely wipe out the *Cannabis* crop in a week (Punja et al., 2019; Garfinkel, 2020).

The viral diseases: Hemp mosaic virus, Hemp streak virus, Alfalfa mosaic virus and Cucumber mosaic virus, also occur frequently in Europe. All these viruses cause pale green leaf chlorosis, especially in fiber hemp. Insects transmit them: aphids, whiteflies and other insects living on leaves (Bakro et al., 2018). However, the existence of viruses is still a subject of investigation, as they manifest as abiotic stress due to the lack of some essential nutrients (Righetti et al., 2018). On the other hand, extracts of essential oils from hemp have great potential for use as natural insecticides in organic agriculture (Benelli et al., 2018; Ona et al., 2021).

2 Conclusions

In this article some of the major pests of energy crops (*Amaranthus* spp., *Cannabis sativa* (L.), *Panicum virgatum* (L.) and *Sida hermaphrodita* (L.) Rusby) were discussed. Ultimately it was observed that these energy crops are threatened by miscellaneous pests, nevertheless, among the most substantial pests are insect mainly moths and

beetles. Furthermore, viral and fungal pathogens such as the Switchgrass mosaic virus, Hemp mosaic virus or *Fusarium* play a great part in damaging energy crops. Pests can have a fundamental economic, environmental, or social impact in the territories they are present. Plant health is especially at risk which is a key factor for crop production, forests, natural ecosystems, and biodiversity. It is necessary to establish criteria to be able to monitor, identify pests and, to conduct their eradication. The best way to preserve bioenergy crops is to use a combination of biological, cultural, mechanical techniques to eliminate destructive species.

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