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Towards the antimicrobial, therapeutic and invasive properties of *Mikania micrantha* Knuth: a brief overview

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ABSTRACT: Plant-derivatives impose a huge momentum in the field of medical science lately due to their wide-spectrum therapeutic attributes. Owing to the emerging drug resistance and hazardous side-effect of synthetic drugs, phytochemicals are now coming into play as a source of new and effective therapeutics. *Mikania micrantha* is a medicinal plant commonly found in tropical Asian countries including Bangladesh. The pharmacological significances of this plant were reported earlier which include a diverse range of antimicrobial and therapeutic potencies. However, the rapid-growing nature and covering surrounding flora reckoned *M. micrantha* as one of the world's most invasive weeds. Therefore, it is essential to understand if the therapeutic essence of *M. micrantha* outweighs its invasiveness. In this brief review, we tried to explore the biological activities of *M. micrantha*. The future perspectives regarding the management of its invasiveness were also highlighted in this limited scope.

KEYWORDS: Antimicrobial, Invasive species, Medicinal plants, *Mikania micrantha*, Phytochemicals.

INTRODUCTION

Mikania micrantha Knuth is a fast-growing tropical herb, also known as mile-a-minute or bitter vine, which belongs to the *Asteraceae* family [1]. It is native to the tropical zones of Central and South America but is now widely distributed in Southeast Asia, Pacific Islands, South China, etc. [1,2]. Traditionally, it has been used as folk medicine in many areas around the world. For example, a poultice made from the leaves of *M. micrantha* is used to treat venomous biting of insects [3,4] and the leaf juice is used to reduce skin rashes and itches [5]. In Jamaica, its most popular uses are for wound dressings and promote the healing of sores as folk medicine [6]. Furthermore, it is used to mitigate stomach ache, jaundice, fever, rheumatism, cold, and respiratory diseases [4]. Modern pharmacological studies provide scientific evidence that bitter vine possesses outstanding therapeutic potencies, *i.e.*, antimicrobial, anti-inflammatory, cytotoxic, anticancer, antidiabetic, antioxidant, and wound healing activities [4,7]. Therefore, *M. micrantha* has gained the attention of natural product chemists because of its numerous biological potencies. Due to its fast-growing nature and invading surrounding flora, however, *M. micrantha* has been recorded as one of the 100 worst invasive alien species in the world [8], and the second most serious weed in South Pacific regions [9].

Natural products have played an important role in the discovery of drugs and therapeutics. Phytochemicals are small molecules with diverse chemical profiles and more "drug-like" than synthetic compounds, hence, they are considered as good candidates for the development of drug leads [10]. In recent decades, the genus *Mikania* under the *Asteraceae* family has been extensively studied due to their diverse chemical compositions [11,12]. For instance, *M. micrantha* has been reported to contain several classes of bioactive chemical substances, *i.e.*, terpenoids (sesquiterpene lactones and diterpenes), polyphenols and flavonoids [12]. Likewise, the presence of various terpene-derivatives, especially mikanolide and miscandenin, is responsible for the antibacterial and analgesic activities of the plant [13,14]. The recent emergence of multidrug-resistance in pathogenic bacteria poses a new threat to our current therapeutic

advances, thereby, pressing urges to find new antimicrobial agents [15].

An adequate amount of research has been done on the biological properties of *M. micrantha* while a few review works were conducted either on its medicinal or invasive activities. To the best of our knowledge, however, no article encompasses both sides of this plant with prospective control management. In this review, therefore, we aimed to explore and summarize both therapeutic and invasive attributes of *M. micrantha* plant. Figure 1 shows the major biological attributes reported previously. The biological activities and their mechanism of actions were reviewed based on the existing pieces of literature.

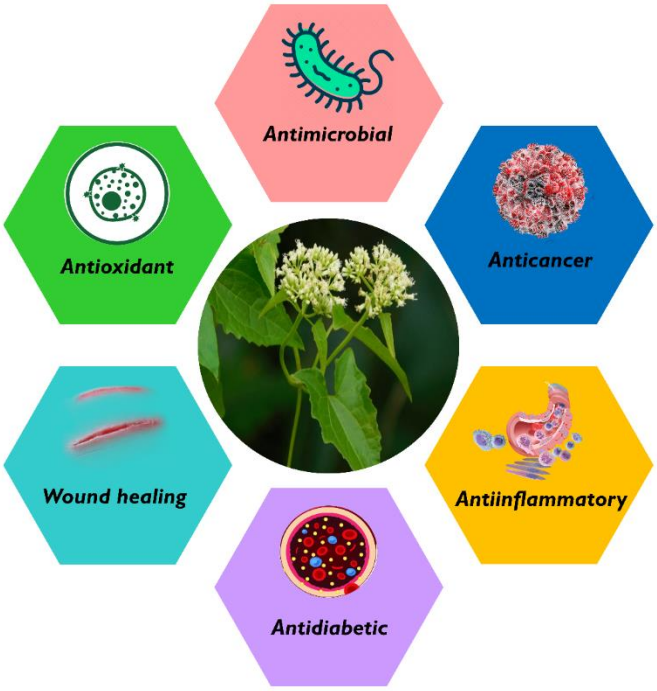

Figure 1. Pharmacological significances of *Mikania micrantha* plant. The central *M. micrantha* photograph was collected from National Inventory of Natural Heritage database (Captured by Cesar Delnatte).

ANTIMICROBIAL ACTIVITIES

Antibacterial properties

Antibiotics have been using since 1940s to treat bacterial infections [16]. Due to the selective pressure involved, the bacteria are prone to develop resistance against antibiotics which is now considered as a major global health concern [15]. Most of the common bacterial pathogens have now become resistant to almost all classes of antibiotics in empirical use [17]. In addition, the discovery of new antibiotics is getting rare. For instance, only one antibiotic named daptomycin was discovered in the last 50 years [18]. Therefore, there is a pressing need to find an alternative therapeutics. Plant-derived phytochemicals could be useful in such scenarios because of their antimicrobial potencies, non-toxic nature, and bioavailability [5]. Plants belong to *Mikania* genus have been reported to possess antibacterial activity against a large number of bacteria [12].

In a study, methanolic extract (at a concentration of 200 mg/ml) of the *M. micrantha* was able to potentially inhibit the growth of six bacterial strains where antibacterial activity against *Bacillus cereus* was equivalent to the antibiotic ciprofloxacin [19]. Also, leaf and flower extracts showed moderate inhibitory activity against the growth of *B. cereus, Escherichia coli, Shigella sonnii* and *Streptococcus pyogenes* [13,14,20]. Furthermore, various extracts of *M. micrantha* containing tannins, flavonoids and polyphenols exhibited potential antibacterial activities against multidrug-resistant pathogenic bacteria *i.e., Pseudomonas aeruginosa, Salmonella typhii, Staphylococcus aureus, Staphylococcus epidermidis, Bacillus subtilis, E. coli*, and *Streptococcus pneumoniae* [13,21,22]. This is plausible because polyphenols have toxicity towards microbial enzyme while structural features of flavonoids may help to gain entry into the bacterial cell which eventually leads to multiple component inactivation [23-24]. Likewise, sesquiterpene lactones (SLs) from different plants provides antimicrobial activity against a wide range of microorganisms including bacteria, virus, and fungi [25]. For instance, *M. micrantha* derived sesquiterpene lactones showed significant inhibitory activity against *S. aureus, B. subtilis, Micrococcus luteus, B. cereus, Ralstonia solanacearum, Xanthomonas oryzae* pv. oryzae, *Xanthomonas campestris* pv. vesicatoria, and *X. campestris* pv. citri [5]. Therefore, *M. micrantha* represents a potential source of novel antibacterial phytochemicals that needs further investigation *in vivo*. A summary of the antibacterial activity by different parts of *M. micrantha* is provided in Table 1.

Antifungal attributes

Approximately a billion people around the world have skin, nail, and hair infections caused by pathogenic fungi. Although most of them are curable, the mortality rate of fungal diseases is similar to tuberculosis [26]. In addition, plant pathogenic fungi living in or on plant tissues have an enormous impact on agriculture that imposes a major challenge to overcome [27]. In response to fungal attack, the plant synthesizes various metabolites as a part of their defense mechanism [28]. Table 1 includes a list of antifungal activities by different parts of *M. micrantha*. The leaf extracts of *M.*

micrantha have an inhibitory effect against the germination of the spore by several fungal species such as *Exserohilum turcicum, Colletotrichum lagenarium, Pseudoperonospora cubensis,* and *Botrytis cinerea* [5]. A study revealed that the presence of glycosides and quinones is responsible for the antifungal activity against the *Fusarium moniliforme, Fusarium eridiforme, Fusarium proliferatum,* and *Sclerotium rolfsii* [29]. Quinone targets the cell-wall polypeptides, membrane-bound enzymes leading to the inactivation of protein synthesis and cellular function [30]. Furthermore, ethyl acetate extracts of *M. micrantha* leaves, flowers and stems were able to completely inhibit the growth of several phytopathogenic fungi, *i.e., Epidermophyton floccosum* var. nigricans, *Microsporum gypseum, Microsporum canis,* and *Trichophyton rubrum* while petroleum ether extract provided significant inhibition [2].

Antiparasitic activities

More than a quarter of the world population is infected with soil-borne helminths like hookworm and *Ascaris* species - several million people are affected by intestinal protozoal diseases, *i.e.,* amebiasis and giardiasis [31,32]. In addition, parasites often cause the death of wildlife as a consequence of the altered behavior of their hosts [33]. For centuries, natural derivatives have been used for the treatment of parasitic diseases. Both *in vivo* and *in vitro* experiments suggest that the plant-derived lactones, alkaloids, and tannins have antiparasitic activity [34]. For example, sesquiterpene lactones of *M. micrantha* have been reported to exhibit significant antiprotozoal activity against *Trypanosoma cruzi* and *Leishmania braziliensis* [35]. Laura *et al.,* 2017 also reported that α and β-unsaturated lactone groups in the sesquiterpene lactone are the major determinants of antiprotozoal activity. Likewise, alkaloids, flavonoids, saponins, phenolic compounds present in the methanolic extract of *M. micrantha* have a mild antihelmintic activity that causes paralysis and death of adult earthworm *Pheretima posthuma* in a dose-dependent manner [36]. Some notable antiparasitic activities of *M. micrantha* are provided in Table 1.

Table 1. Previously reported biological attributes of the different part of *Mikania micrantha* plant.

Biological activity	Plant parts	Effective doses	Targets	Nature of actions	Class of compounds	Compounds	Ref
Anticancer	Leaf	500-1000 mg/kg BW[a]	Ehrlich ascites carcinoma (EAC) cells in Swiss albino mice	Arresting the tumor growth; Decreasing the volume and weight of tumor as well as the viable tumor cell count	Flavonoids and saponins	-	[42]
		167.16–98.07 µg/ml 196.27–131.56 µg/ml	K562 cell line; and HeLa cell lines	Inducing apoptosis in both K562 and HeLa cells with reduction in tumor weight	Flavonoids	-	[43]
	Whole plant	20 µg/ml	HL-60 cell line	Apoptosis in HL-60 cell line and reducing cell viability vigorously	-	-	[74]
	Aerial parts	-	CNS glia, breast, and lung tumor cells	Antiproliferative activity against three cancer cell lines mediated by specific structural feature of the phytochemicals	Sesquiterpene lactones	Mikanolides, miscandenine, achalensolide, xerantholide, micrantholides, and 8-epi-mikanokryptin	[3]
Anti bacterial	Whole plant	200 mg/ml	*B. subtilis MTCC441, B. cereus MTCC430, S. aureus MTCC96, E. coli MTCC739, P. aeruginosa MTCC1688, and S. epidermidis MTCC435*	Inhibited both gram positive and negative strains with similar potency	Alkaloids, phenolics, tannins, steroids, and glycosides	-	[19]
		20 µl	*P. aeruginosa, S. typhii, S. aureus, and S. pneumoniae*	Inhibited both gram positive and gram negative bacteria	Tannins, polyphenols, alkaloids, saponins, and triterpenoids	-	[74]
		300 µg/disc	*S. aureus, B. cereus, E. coli*, and *S. sonnii*	Mild to moderate inhibitory activity against four bacteria	-	-	[14]
	Leaf and	500 µg/ml (MIC)[b]	*S. aureus* MTCC1927,	Moderate inhibitory	-	-	[2]

	Flower	1000 µg/ml (MBC)[c]	and *S. pyogenes* MTCC3160	potency against both bacteria			
		-	*S. epidermis* ATCC12228	Significant inhibitory activity against *S. epidermis*	Alkaloids, flavonoids, and tannins	-	[22]
	Leaf	62.5-125 mg/l (MIC) 125-250 mg/l (MBC)	*S. aureus, B. subtilis, M. luteus, B. cereus, R. solanacearum, X. oryzae* pv. *oryzae, X. campestris* pv. *vesicatoria, and X. campestris* pv. *citri*	Antibacterial effect against all bacterial isolates	Sesquiterpene lactones	Deoxymikanolide, scandenolide, dihydroscandenolide, mikanolide, dihydromikanolide, and m-methoxy benzoic acid	[5]
	Stem, Leaf, Inflorescence	0.5 – 4.0 µg/µl (MIC)	*B. subtilis* ATCC6633, and *E. coli* ATCC6051	Both strains were sensitive to all three plant extracts	-	-	[21]
	Leaf	21.44-53.18 mg/l (IC_{50})[d]	*E. turcicum, C. lagenarium, P. cubensis,* and *B. cinerea*	Inhibition of spore germination of fungal species	Sesquiterpene lactones	Deoxymikanolide, scandenolide, dihydroscandenolide, mikanolide, dihydromikanolide, and m-methoxy benzoic acid	[5]
Antifungal	Aerial parts	0.5-2.0 mg/ml	*E. floccosum* var. nigricans, *M. canis, M. gypseum,* and *T. rubrum*	Completely inhibited the growth of tested fungi	-	-	[2]
	Whole plant	-	*F. moniliforme, F. eridiforme, F. proliferatum, and S. rolfsii*	Different extracts varied in antifungal activities; methanol extract showed good inhibitory activity against *F. moniliforme* and *F. proliferatum*	Glycosides, and quinones	-	[29]
Anti-parasitic	Aerial parts	-	*T. cruzi* (epimastigotes), and *L. braziliensis* (promastigotes)	Significant antiprotozoal activity was found for organic extract while aqueous extract showed low to moderate activity	Sesquiterpene lactones	Mikanolide, deoxymikanolide, dihydromikanolide, and scandenolide	[35]
	Leaf	50 mg/ml	*P. posthuma*	Paralysis and death of adult earthworm	Alkaloids, flavonoids, saponins, phenolics, and tannins	-	[36]
	Leaf	200 mg/kg BW	Carrageenan-induced rat paw edema	Inhibition of acute and sub-acute inflammation	-	-	[39]
	Whole plant	-	Human erythrocytes	Inhibition of inflammation at concentration dependent manner	Terpenoids and tannins	-	[14]
Anti-inflammatory	Aerial parts	1 µM	Mouse ear model edema induced by tetradecanoylphorbol acetate (TPA)	Inhibition of ear inflammation	Sesquiterpene lactones	15-O-4′-hydroxy-methacryl-micrantholide, 15-O-4′-hydroxymethacryl-14-acetoxy-micrantholide, 15-O-3′-chloro-2′-hydroxy-isobutyryl-micrantholide, and 15-O-2′-hydroxyisobutyryl-micrantholide	[3]
	Stem, Leaf Inflorescence	1 mg/ear	TPA-induced male mice ear edema	Significantly inhibited ear inflammation in mice	-	-	[21]
Anti-diabetic	Leaf	150 mg/kg BW 200 mg/kg BW	Alloxan-induced diabetic male Spargue Dawley rats	Reduction of blood glucose level after 20 days	-	-	[48, 49]
Anti-oxidant	Aerial parts	16.24–21.67 µM (EC_{50})[e]	2,2-diphenyl-2-picrylhydrazyl (2,2-DPPH)	DPPH radical scavenging activity	Phenolic compounds	(+)-isolariciresinol, caffeic acid, ethyl protocatechuate, and protocatechuic aldehyde	[54]
	Leaf	41.8 µg/ml (IC_{50})	1,1-DPPH	DPPH radical scavenging activity	Alkaloids, flavonoids,	-	[36, 53]

					saponins, phenolic compounds and tannins		
	Whole plant		Male Wistar strain albino rats	Moderate wound healing activity	-	-	[59]
Wound healing	Leaf	7 µg/ml and 15 µg/ml	BJ cell line (human fibroblast), Rats	Wound healing significantly accelerated at lower concentrations; and Improving the percentage of wound contraction	-	-	[48, 57]

[a]BW stands for bodyweight; [b]MIC denotes the minimum inhibitory concentration; [c]MBC is the minimum bactericidal concentration; [d]IC_{50} defines the concentration of an extract needed for 50% inhibition *in vitro*; and [e]EC_{50} is the concentration of a drug that provides half-maximal response.

THERAPEUTIC ATTRIBUTES

Anti-inflammatory attributes

There are many side effects associated with the administration of non-steroidal anti-inflammatory drugs (NSAIDs) including the risk of gastrointestinal (GI) and cardiovascular complications [37]. Medicinal plants that's possess anti-inflammatory potency with little or no side effects have been using by Africans for centuries [38]. For example, ethanolic extracts of *M. micrantha* leaves were found to have anti-inflammatory activity in a dose-dependent manner. Deori *et al.,* 2017 reported that at a certain dose it can reach up to the effect provided by aspirin at the dose level of 100 mg/kg. Moreover, the study speculated a significant weight reduction in rat adjuvant arthritis at a dose of 200 mg/kg and 400 mg/kg [39]. In another study, ethanolic extracts of *M. micrantha* showed higher anti-inflammatory activity than *M. scandens* but lower than that of aspirin which was estimated based on the ability to inhibit hypotonic solution and heat-induced hemolysis of human erythrocytes *in vitro* [14]. Furthermore, micrantholides from *M. micrantha* has exhibited better anti-inflammatory effect in tetradecanoylphorbol acetate (TPA) induced mouse ear edema (Table 1) [3]. Moreover, hexane and ethyl acetate extracts of *M. micrantha* stems and leaves also provided a significant reduction of inflammation *in vivo* (Table 1) [21]. Therefore, further investigations are necessary for the identification of relevant bioactive chemicals alternative to NSAIDs.

Cytotoxic and anticancer potencies

Cancer is the second major global disease accounting for ~13% of global death each year [40]. Today's cancer treatments are mostly chemotherapeutics and have plenty of side effects. Therefore, natural derivatives with less toxicity could be a better replacement for those synthetic drugs. Many plants in the *Asteraceae* family are found to have cytotoxic effects against cancer cells [41]. Likewise, various extracts and phytochemicals from *M. micrantha* are reported to have cytotoxic and anticancer potentials (Table 1). For instance, *M. micrantha* derived flavonoids have shown a dose-dependent anticancer effect against Ehrlich ascites carcinoma cells in Swiss albino mice [42]. Also, an aqueous extract obtained from *M. micrantha* showed *in vitro* anticancer activity against human cancer cell lines, K562 and HeLa [43]. Dou *et al.,* 2013 also reported *in vivo* growth inhibition of murine Sarcoma 180 cells (S180). In their study, the growth inhibition of S180 occurred via antiproliferation, apoptosis, and cell cycle arrest. Lack of cellular apoptosis causes malignancy, hence, restoring the cellular regulation on programmed cell death could reduce cancer growth. In addition, plenty of studies suggested that using apoptosis in cancer treatments is feasible [44]. Among other phytochemicals, sesquiterpene lactones (SLs) are known to exhibit major antiproliferative effects [25]. Nine SLs isolated from the aerial parts of *M. micrantha* provided cytotoxic activities on three cancer cell lines due to their specific structural features [3]. These structural features may cause specific damage to the oncogenic marker included in the tumor cells. These studies concluded that *M. micrantha* may contain phytochemicals with anticancer potency. However, further investigation of their mechanism of action is warranted to extrapolate their potentiality in clinical practice.

Antidiabetic characteristics

According to the International Diabetes Federation (IDF), diabetes affects about 285 million people across the world [45]. Most commonly used oral and injectable antidiabetic agents have different side effects like nausea, vomiting, diarrhea, cardiovascular complications, etc. [46]. Therefore, natural derivatives with fewer side effects and efficacy can be used as an alternative antidiabetic agent. Many plants under the *Asteraceae* family have been reported to provide antidiabetic activity [47]. For example, extracts of *M. micrantha* is reported to have a hypoglycemic effect

(Table 1) [48]. The blood glucose level of alloxan-induced diabetic rats was significantly reduced ($p<0.05$) when treated with ethanolic extract of *M. micrantha*, probably due to the stimulation of insulin-producing β-cells of the pancreas [49]. Furthermore, Nurdiana *et al.*, 2013 reported a 72% reduction in blood glucose level which is higher than metformin, a first-line type-2 diabetes medicine [48]. They suggested insulin-mimetic activity could be associated with this process.

Antioxidant properties

Aerobic metabolic processes within the cell produce reactive oxygen species (ROS) which leads to cell damage and even cell death [50]. Antioxidants reduce the oxidative stress in cells by quenching those free radicals [51]. A large number of plant-derived compounds have been reported to possess free radical scavenging activity [52]. The methanolic extract of *M. micrantha* leaves showed significant antioxidant activity in ferric-reducing antioxidant potential (FRAP) assay (Table 1). In FRAP assay, the antioxidant phytochemical reduces iron from ferric (Fe^{3+}) to ferrous (Fe^{2+}) state [53]. In addition, phenolic compounds from *M. micrantha* exhibit more potent 2,2-diphenyl-1-picrylhydrazyl (2,2-DPPH) radical scavenging activity than L-ascorbic acid (Table 1) [54]. These phenolics act as chain-breaking antioxidants by shifting its hydrogen (H) atom as proton from hydroxyl (OH) group to the chain carrying ROO• radicals [55]. Furthermore, methanolic extract of *M. micrantha* showed prominent antioxidant activity on 1,1-diphenyl-2-picrylhydrazyl (1,1-DPPH) which may be due to the presence of the phenolic compounds in the extract [36].

Wound healing aspects

Medicinal plants are reported to promote wound healing by boosting blood clotting and fighting infection with lower side effects [56]. Traditionally, herbal medicine used in India and China for wound dressing and healing of sores by our ancestors because of its fascinating healing power. The ethanolic extract of *M. micrantha* showed a significant acceleration in wound healing on fibroblast cells even in a lower dose (Table 1) [57]. Histological studies suggest that the ethanolic extract of *M. micrantha* improves the healing process on diabetic wounds in rats by increasing granulation tissue and collagen deposition [48]. For wound healing, collagen protein acts as a scaffold in connective tissue and deposition of collagen results in increased tensile strength of the wound site [58]. Moreover, an ointment made from *M. micrantha* showed a moderate rate of wound healing in male Wistar albino rats probably by enhancing collagen concentration [59].

INVASIVE CHARACTERISTICS

Biological invasion has become one of the most critical environmental problems in the 21st century which leads to world-wide extensive economic losses [60]. *M. micrantha* has been listed among the top 100 worst invasive alien species [8]. Rhizosphere soil of *M. micrantha* causes a significant decrease (~21%) of shoot length of *Panicum antidotale*. Further, leaf leachate of genus *Mikania* contributes to the decreased rice seed germination in non-sterile soil [61]. In a study, *M. micrantha* is negatively correlated with *Ageratum conyzoides*, *Bidens pilosa*, *Borreria latifolia*, *Digitaria sanguinalis*, and *Galinsoga parviflora* [62]. Moreover, the leaf extract of *M. micrantha* inhibited the germination of *Raphanus sativus* and *Oryza sativa* due to the presence of allelochemicals in the extract [63].

In Kolkata, the state capital of West Bengal, a total of 86 sites were surveyed to identify the presence of this exotic alien plant. The survey revealed that 13 sites were highly infested with *M. micrantha* while moderate infestation was found at 39 sites [64]. The rapid spreading of *M. micrantha* is responsible for yield loss by several cash crops, *i.e.*, sugarcane, lemon, orange, and banana [65]. Due to its involvement with tea, rubber, and other crop infestation, *Mikania* has been declared a class-I weed in Queensland (Australia) under the Rural Land Protection Act. Moreover, it has been ranked amongst the top three worst weed plant by the Secretariat of the Pacific Community [66].

BIOLOGICAL CONTROL

Despite the potential applicability, the invasiveness of *M. micrantha* should be controlled as a part of crop management as well as to protect the biological diversity. There are two major weed control strategies - chemical and mechanical approaches [67]. For example, chemical herbicides including atrazine, bensulfuron-methyl, and prometryne have significant bioactivity and selectivity to the germination and seedling of *M. micrantha* plant [65]. Furthermore, herbicides such as 2,4-dichlorophenoxyacetic acid, sulfometuron-methyl, and glyphosate are widely used in farming systems and forest systems to control *M. micrantha* infestation [68]. On the other hand, the mechanical method is also used to control various weeds including *M. micrantha*. For instance, a study suggests a manual cutting strategy before flowering in Nepal which results in a 91% mortality of *M. micrantha* [69]. However, mechanical

methods cause soil disturbance which may consequently lead to erosion. Likewise, chemical-based herbicides can compromise the soil fertility and environment that pose serious threats to humans and wildlife. Moreover, certain weeds are prone to develop resistance against these chemicals [68].

Therefore, biological control could be more beneficial over the conventional methods due to several reasons - permanent control of weeds, host-specific control, cost-effectiveness and low health risk [70,71]. The term 'biological control' refers to the control of weeds by introducing natural antagonistic pathogens. Interestingly, several arthropods are known to interfere with the growth of *M. micrantha* plant. For example, *Acalitus sp.* causes shortened internodes with reduced flowering and *Liothrips mikaniae* causes small to moderate lesions on *M. micrantha* leaves [72]. Furthermore, co-cultivation of sweet potato (*Ipomoea batatas*) and *M. micrantha* results in the reduction of shoot length and increased rate of *M. micrantha* inhibition [62]. The rust fungus *Puccinia spegazzinii* reduced *M. micrantha* population by ~50% through selective growth suppression without affecting the other plants [73]. These antagonistic pathogens can be used to control the overgrowth of *M. micrantha*. In Papua New Guinea, for instance, *P. spegazzinii* was released in 15 provinces as a specific control strategy against *M. micrantha* infestation to compensate for the economic loss due to reduced yields and high weeding cost [74]. However, more understanding of *M. micrantha* genetics is needed for fine-tuning the population-dependent effective management approaches [68]. Thus, biological control could play a large role in mitigation and adaptation strategies used to maintain biological diversity as well as human well-being by protecting food and fiber resources.

CONCLUSION

In a nutshell, *Mikania micrantha* is the reservoir of numerous compounds with pharmacological value in spite of the invasiveness. Based on the previous studies, these bioactive chemicals has been found to hold promising therapeutic value regarding their use in various pathological conditions including pathogen inflicted diseases, malignancies, diabetes, tissue inflammation, and severe wounds. However, further investigations are warranted to shed light on the molecular mechanisms behind their biological actions that are essential in functional drug development. Importantly, considering the rapid and ubiquitous growth of bitter vine, it could also be used in the development of safe and cost-effective medical treatments for developing countries like Bangladesh. For this purpose, the extensive loss due to its invasive nature should be minimized through eco-friendly biological control and novel genetic engineering approaches.

AUTHOR CONTRIBUTIONS

ZN conceived the idea; ZN, MMS, and ZH wrote the draft manuscript; ZN critically revised and finalized the manuscript; ZN supervised the whole work. All authors approved the final version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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