Pertanika J. Trop. Agric. Sc. 42 (2): 421 - 434 (2019)

PERTANIKA JOURNALS

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Review Article

Gynura procumbens: Agronomic Practices and Future Prospects in Malaysia

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ABSTRACT

Good agronomic practice is a key to a successful crop production aiming at high yield and quality in small or large scale planting. *Gynura procumbens* (Lour.) Merr. (Family Asteraceae) is a herbal plant rich in phytochemical compounds of wellbeing benefits to the consumers. Suitable and complete technology on agronomic practices such as cultivation technique, fertilization application, water requirement, weed control and pest and disease management of *G. procumbens* or locally known as Sambung Nyawa for the Malaysian environment can ensure quality product and high yield. This may attract local producers and smallholders to cultivate this medicinal plant commercially. Complete technology package documented for commercial planting of *G. procumbens* may encourage its planting which would ensure the sustainable supply of *G. procumbens* raw materials for the pharmaceutical and health industries. Suitable agronomic practices adopted contribute to sustainable commercial production of *G. procumbens*. It endeavours to support the country's Entry Point Project under The Agriculture National Key Economic Area (NKEA) to become a potential hub for the manufacturing of high-value *G. procumbens* based herbal products as well as other herbal species. Therefore, it is crucial to develop and to adopt the necessary agronomic practices for the commercial cultivation for this medicinal herb to support the demand for the industry while directly increase farmers' farm profit.

Keywords: Agronomic practices, bioactive compound, cultivation, *Gynura procumbens*, medicinal plant

ARTICLE INFO

Article history:
Received: 04 December 2018
Accepted: 31 March 2019
Published: 30 May 2019

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ISSN: 1511-3701
e-ISSN: 2231-8542

INTRODUCTION

Benefits of medicinal plants or herbs are acknowledged by the people nowadays due to the belief that natural remedies are reliable and more effective compared to conventional drugs (Alsarhan et al., 2014). For hundreds of years, nature has been the resource of medicine to treat ailments such as gout, high blood pressure, diarrhoea and skin infection (Shafaei et al., 2014), with large number of herbal preparations have been concocted from natural sources and used in traditional medicine. In Malaysia, more than 2000 species of medicinal plants were recorded which some have been used in herbal products manufacturing such as those with important components of hypoglycemic agents for the treatment of diabetes (Bukhori et al., 2015).

In fact, Malaysia has been acknowledged as one of the 12 mega- diverse countries by the United Nations Environment Programme (UNEP) as to harbour the majority of the earth's species (Nasir et al., 2015). In addition, since the Malaysian government had launched the Economic Transformation Programme (ETP) in 2010 through the implementation of National Key Economic Areas (NKEA) including in the agriculture sector, production of herbs and the downstream products in Malaysia has significantly increased. The importance and demand of medicinal plants in Malaysia can be discerned from the Herbs and Spices Statistics 2016 reported by Department of Agriculture Malaysia. In 2013, a total of 1,298 hectares of planted area were utilized to produce 8,428 metric tonnes of herbal raw materials. Herbs production in 2014 increased greatly by 37% with 13,567 metric tonnes production using 2,176 hectares of planted area. Looking at this progressive demand for herbs or medicinal plants, *G. procumbens* has been identified one of 18 selected herbs under the Agriculture NKEA Initiative for Herbal Subsector in 2010 (Ministry of Agriculture and Agro-Based Industry [MOA], 2018).

Origin and Distribution

Gynura procumbens is one of the most common medicinal plants belonging to the Asteraceae family which is widely distributed in Africa (Sukadeetad et al., 2018) and tropical regions of South East Asia including Malaysia, Indonesia, Thailand, Vietnam, Philippines, Myanmar and China (Mou & Dash, 2016; Nasir et al., 2015; Tan et al., 2016). The genus *Gynura* comprises 44 species and is widely distributed from tropical Africa to South East Asia through southern China, Japan, Southeast Asia and New Guinea into northern Australia. Ten species were enumerated in Thailand (Vanijajiva, 2009). In Malaysia this species has its distribution limited to the western part of Peninsular Malaysia (Keng et al., 2009).

Gynura procumbens is commonly known as Sambung Nyawa in Malay which means "prolongation of life", whereas in Chinese, it is named as "bai bing cao" which bears the meaning of "100 ailments" (Rohin et al., 2018). Other vernacular names for *G. procumbens* according to Global Information Hub on Integrated Medicine

(Global Information Hub on Integrated Medicine [Globinmed], n.d.-a, "*Gynura procumbens* (Lour.) Merr.", para. 3) are listed in Table 1.

Table 1
Vernacular names for G. procumbens

Country	Vernacular names
Malaysia	Daun dewa, dewa raja, akar sebiak, kelemai merah, kacham akar
Indonesia	Sambung Nyawa, daun dewa, kalingsir (Sundanese)
Cambodia	Chi angkam
Thailand	Pra-kham dee khwaai, ma kham dee khwaai (Pattani), mu maeng sang (Chumphon)

Morphological Characteristics and Environmental Requirement

Gynura procumbens is a shrub plant that can grow about 1-3 m in height and can easily be propagated from stem cuttings. The plant grows vertically, or sometimes the edge collapses and forms roots. The stem is purplish in colour and has fleshy characteristics. The stem is also angular and has many branches with length of node shortens from base to shoot. The leaves are ovate-elliptic or lanceolate shape that alternately arranged (Rahman & Asad, 2013). The upper leaf surface is yellowish green colour when matures and light green colour on the lower leaf surface. The size of petiole is between 0.5-1.5 cm long, leaf width between 1-5.5 cm and leaf blades measure up to 12.5 cm. In Malaysia, it is very rare for *G. procumbens* to produce flowers, but according to Wiart (2002), *G. procumbens* has purple tubular bisexual flowers. This plant can grow well in shady areas with 25-50% rate of light intensity. The suitable soil pH is around 5.5-7.0, whereas for the air temperature is between 20-30°C and preferably of medium humidity with annual rainfall between 1500-2500 mm.

Main Uses

Gynura procumbens is an annual evergreen shrub with the fresh leaves usually used as vegetables in cooking. In Malaysia, fresh leaves of *G. procumbens* are usually used as salad or *ulam* (Hew & Gam, 2011) and are eaten raw. Previous studies have shown that leaf contents did not have any toxic effect (Rohin et al., 2018). Apart from being consumed in the diet, *G. procumbens* also traditionally has been used to treat various ailments such as rash, constipation, hypertension, migraines, diabetes mellitus, urinary infection, cancer and as anti-inflammatory and anti-allergic agents (Perry, 1980). In Malaysia, *G. procumbens* is used by the traditional practitioners to control the blood glucose levels of diabetic patients in the form of decoction (Akowuah et al., 2002). They found that the benefits of consuming *G. procumbens* were related to the amount of bioactive compounds present, such as saponins, flavonoids and terpenoids. Whilst in Indonesia and Vietnam, it is used to relieve kidney discomfort and for the treatment of fever, respectively (Tan et al., 2016).

PRODUCTION AND CULTIVATION

Preparation of Cuttings

Propagation of *G. procumbens* is done through stem cuttings as planting materials. The middle part of cuttings with a total of 5 nodes are selected from 2 months old mother plants. The shoot part is not suitable to be used for propagation since it is still young, too sensitive to wet condition and can lead to infection of stem rot disease. Rooting hormone (Seradix 1) can be used to encourage root growth. Cuttings can be propagated in plastic cups containing sand or peat moss, rather than using trays to minimize the destruction of the root system during the transplanting process. During the propagation stage, suitable places to place the cuttings can be one of the reasons for better growth. Normally, a glass house or other shaded area is suitable. During the propagation stage also, *G. procumbens* cuttings are quite sensitive to wet condition since it can lead to stem rot problems. The cuttings need to be monitored and watering daily if using sand as the medium or every two days if peat moss is used. This is because these two media have their own characteristics in terms of absorption and water retention capacity. Sand medium is more porous that allows water to drain easily whereas peatmoss remains moist and retains considerable amount of water after being watered. The stem cuttings after reaching 6 to 8 leaves with 4 to 6 weeks old are ready to be transferred to the field or shade house. The growth process of cuttings until 6 weeks of propagation is shown in Figure 1.

Field Preparation

To achieve maximum crop growth in the field, good land preparation is crucial. The land is cleared before ploughing to remove shrubs and weeds. About 1-2 weeks before the transplanting process, the planting area is ploughed and rotovated to prepare for planting. Planting beds with size 1 m

(a) (b) (c)

Figure 1. (a) One week old of stem cuttings propagated in the peatmoss medium; (b) Rooted cuttings after three weeks of propagation; (c) *Gynura procumbens* plants at six weeks after propagation and ready to be transplanted

wide, 3 m long and 30 cm height raised from the ground are prepared according to the number of rooted cuttings to be transplanted. According to the Globinmed (n.d.-b, "Sambung Nyawa", para. 5) the recommended bed size is about 120 cm wide with a distance of about 30 cm between the beds.

(a)

(b)

(c)

Figure 2. Suitable planting methods for *G. procumbens* including on (a) planting beds; (b) pots; and (c) polybags

Planting

For successful planting of the *G. procumbens*, cuttings with 6 weeks old are most suitable to be transferred to the field. There are several methods of planting that can be applied such as planting on the bed, pot or polybag (Figure 2). Holes with 10 cm depth are prepared on planting beds for the planting process. Rooted cuttings are carefully removed from the plastic cups to avoid any disturbance of the root system. A planting distance of 20 to 35 cm between plants and 20 cm within rows equivalent to the density of 15 to 25 plants per m^2 is suitable for production of high yielding *G. procumbens*. Planting that is done using polybag can be arranged with the spacing 1 m x 1 m (Globinmed, n.d.-b, "Sambung Nyawa", para. 6).

Fertilizer Application

Gynura procumbens can be fertilized using organic and inorganic fertilizers for optimum crop growth. Chicken manure is one of the most suitable organic fertilizers that can be applied to *G. procumbens*. Chicken manure as a source of organic fertilizer is recommended to be applied with a rate of 300 kg N/ha. Half of the total fertilizer is applied 1-2 weeks before transplanting and the balance of the fertilizer applied after 2 weeks transplanting.

Irrigation

Gynura procumbens are water loving plants and optimum water content in soil is required for maximum growth (Globinmed,

n.d.-b, "Sambung Nyawa", para. 6). A drip irrigation and sprinkler systems are suitable to be used. Plants need to be watered at least twice a day, in the morning and afternoon, and no irrigation is needed during a rainy season.

Weed Control

Weeding process of the planting area is normally done manually every 1-2 weeks after planting. Plastic mulching using silver shine to cover the surface of the planting bed can also be used for weed control (Figure 3). The area between planting beds can also be covered using silver shine to control weed growth.

Figure 3. The use of plastic mulching of silver shine to cover the planting bed surface to control the growth of weeds in the planting area

COMPOSITION OF BIOACTIVE COMPOUNDS IN *Gynura procumbens*

Extracts from plant have been used as traditional remedies for certain diseases due to the presence of biologically active compounds that have medicinal properties which can contribute to the prospects for new drug leads. For example, *G. procumbens* is culturally acceptable to many medicinal purposes because of its efficacy in the traditional management of diabetes mellitus. Beneficial effects of *G. procumbens* were described for pharmacological properties such as anti-inflammatory, anticancer, antidiabetic, anti-herpes simplex virus activity, anti-ulcerogenic activity, vasorelaxant activity and antiplasmodial activity (Mou & Dash, 2016; Tan et al., 2016).

A significant work was carried out to identify and isolate the chemical constituents from different extracts of *G. procumbens*. Numerous studies have demonstrated that various extracts of *G. procumbens* contained several bioactive chemical constituents such as flavonoids, saponins, tannins, terpenoids and sterol glycosides (Akowuah et al., 2002; Kaewseejan et al., 2012; Zahra et al., 2011). Previous studies also reported that *G. procumbens* leaves extracts contained rutin, kaempferol and two potential antioxidant components which are kaempferol-3-O-rutinoside and astragalin (Rosidah et al., 2008). A comprehensive work done by Kaewseejan and Siriamornpun (2015) showed that the individual bioactive compounds in *G. procumbens*, were different, especially gallic, p-coumaric and ferulic acids for phenolic acids, and myricetin, quercetin and kaempferol for flavonoids (Figure 4).

Among phenolic compounds, flavonoids are widely distributed in the plant kingdom and they were reported to exhibit strong antioxidant activity (Galati & O' Brien, 2004; Havsteen, 2002; Lila, 2004). The antioxidative characteristics of phenolic compounds were related to the number of hydroxyl group position (Arora et al.,

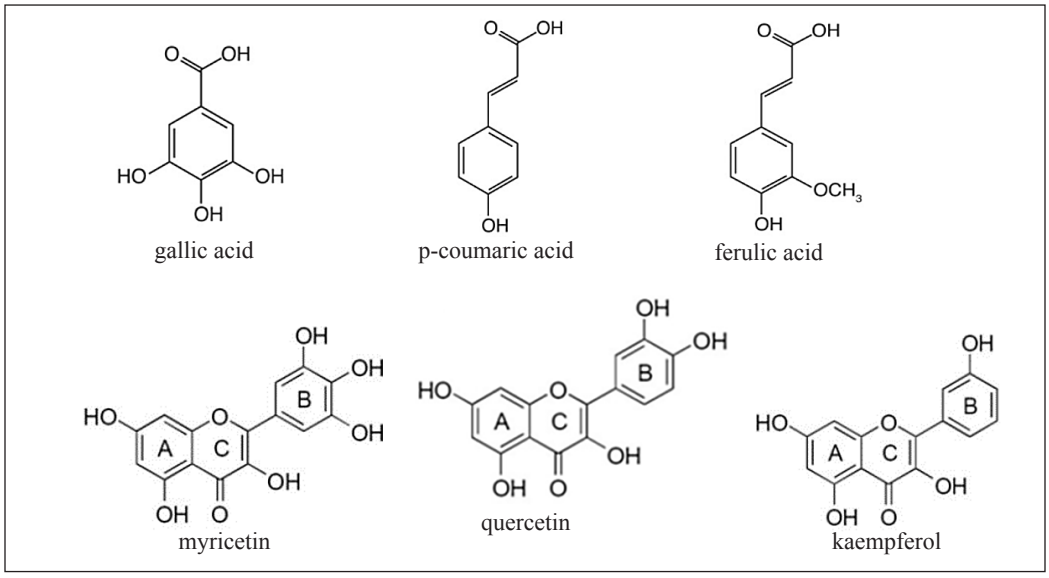

Figure 4. Structures of some phenolic acids and flavonoids found in the leaves of *G. procumbens*

1998). Due to reducing activities of phenolic hydroxyl groups, flavonoids are able to donate more hydrogen. On the other hand, through delocalization of phenoxy radical products, flavonoids can protect against various disease damages from reactive oxygen species (ROS) (Verma et al., 2012).

PESTS AND DISEASES

Plant protection is the practice of managing weather, weeds, pests and diseases that damage or inhibit the growth of fruits, vegetables and other horticultural crops. The practice includes either reducing the plant density that causes plants to suffer stunted growth and their death or causes lower production capacity by reducing the yield or quality of agricultural produce. Proper crop protection is important to produce higher quality crops with minimal wastage (Strickland, 1969). In general, the plants are known to be attacked by a number of pests which include mites, aphids, nematodes, rodents, birds, slugs and snails whereas plant pathogens include fungi, bacteria and viruses. Weeds have also affected agricultural production by competing for nutrients with the crops (Bohmfalk et al., 2011; Flint, 1998; James et al., 2010). Apart from the above pests, humans also suffer crop losses from other abiotic causes such as lack or excess of water during the crop's growth season, extreme temperatures (high or low) as well as improper nutrient supply. Biotic stresses have the ability to reduce production substantially in various ways which can either be qualitative and/or quantitative (Nagarajan & Nagarajan, 2009).

Gynura procumbens is relatively pest-free plant, however few instances of whiteflies and mites attacks during the hot seasons were recorded. Similarly, leaf miners, mealy bugs, aphids, caterpillars, snails and slugs were also partially reported.

However, *G. procumbens* seemingly do not appear to be susceptible to any pests or diseases in the tropical climate. Apart from insect pests, plant diseases and viruses have also been found to associate with this herbal plant.

Insect Pests

Small insects such as whiteflies and aphids are found on new stems on the underside of the leaves. They suck the fluids from the plant and leaving a honey dew substance behind. The leaves turn pale yellow and then black due to the promotion of sooty mold on leaves that further disturb the process of photosynthesis. Similarly, leaf miners create small mines inside leaf epidermis and green leaves become stunted in growth and yellow in color and drop on the soil. Small whitish maggots feed between the leaf surfaces. Damage appears as winding trails in leaf tissue. As mines enlarge, they may merge and from large, light-colored blotched areas. Feeding lasts 1 to 3 weeks. They may pupate in the leaf or in the soil at 0.6 cm depth and flies after emergence in 2 to 4 weeks (Murakami et al., 2000).

Moreover, various species belong to order Lepidoptera and green grasshopper (*Acrida turrita*) voraciously feed on leaves of *Gynura* and many of them are among the most serious of agricultural pests. In fact, many moth species are best known in their caterpillar stage because of the damage they cause to fruits and other agricultural produce, whereas the moths are obscure and do no direct harm. This insect pest causes much damage, mainly by eating the leaves (Figure 5). The propensity for damage is enhanced by mono- cultural farming practices, especially where the caterpillar is specifically adapted to the host plant under cultivation. Therefore, caterpillars are so critical of *G. procumbens* because the consumed part is the leaf and result in the decreased production of leaves and photosynthesis process.

(a)

(b)

Figure 5. (a) Caterpillars; (b) Green grasshopper (*Acrida turrita*)

Diseases

There are various classes of phytopathogenic bacteria such as *Xanthomonas* (Tudor-Nelson et al., 2003) and *Erwinia* (Echandi & Moyer, 1979), which were reported to attack on *G. procumbens* plants (Figure 6). The *Xanthomonas* species can cause bacterial spots and blights of leaves, stems and fruits on a wide variety of plant species

(Boch & Bonas, 2010) and is predominantly observed on citrus plants. Likewise, *Erwinia* spp. is also an imperative plant disease and its occurance were reported from soil and in different plants particularly potato (Burr & Schroth, 1977). These plant diseases do not only provide the quantitative loss in order to cause reduction in the photosynthetic area, but also responsible for qualitative loss in stunting the growth of plants and resulted in the depreciation of commercial value of the fruits (Bonini et al., 2007). The attack of such diseases on *Gynura* is of great concern to researchers as it requires the integrated plant disease management to supress its further expansion. Other than bacteria, virus disease e.g. broad bean wilt virus (BBWV) could also infect economically important horticultural and ornamental crops (Taylor & Stubbs, 1972). It is transmitted by aphids, mostly *Aphis gossypii* and *Myzus persicae.* In Korea, natural infections of BBWV on number of vegetables were reported and it increased gradually (Cho et al., 2007; Choi et al., 2001; Lee et al., 2000).

Wilt and root rot diseases also infect *G. procumbens* and they are caused by fungal pathogen. Soil-borne fungi are wide-spreading with more than ten different species are known to infect roots, causing wilt or root rot diseases in plants. This disease attacks during the early stage of propagation, which causes the stem is to be infected with stem rot disease (Figure 7). Symptoms of wilt are more noticeable under reduced moisture and hot conditions and are often mistakenly diagnosed. Infected plants have brown vascular tissue in the roots and stems and show wilting of the stem tips. Root rot is a disease that attacks the roots of plant growing in wet or damp soil. This decaying disease can cut the life short of just about any type of tree or plant and has symptoms like poor growth, wilted leaves, early leaf drop, branch dieback, and eventually death. Several fungal pathogens that cause wilt disease in plants are *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp. and *Phytophthora* spp.

Other species of *Gynura*, *Gynura bicolor* (Roxb. ex Willd.) DC. known as Okinawa spinach or hong-feng-cai can also be infected with blight and wilt symptoms in commercial vegetable farms in Changhua, Taiwan (Shen et al., 2011). Symptoms included light brown-to-black blight lesions developed from the top of the stems to the petioles and extended to the base of the

Figure 6. Bacterial infection on *Gynura procumbens*

(a)

(b)

(c)

Figure 7. (a) Root disease; (b) wilt disease; and (c) stem rot disease on cuttings of *G. procumbens* during propagation stage

leaves, with severely infected plants and they eventually caused the casualty to the plants. The disease incidence amounted to approximately 20% (Shen et al., 2011). *Gynura bicolor* is a perennial herbaceous plant in the family Asteraceae. It is an important Chinese vegetable and commonly used as Chinese herbal medicine. In 2010, a severe leaf spot disease was observed on *Gynura* grown in the main production areas in Tong Nan County, Chongqing City, China (Shen et al., 2011). Some farms experienced 60% disease incidence. Symptoms usually began on the lower leaves, as circular to elliptical or irregular spots with concentric rings. Individual spots were dark brown with grayish centers, sometimes coalescing and leading to extensive necrosis. The fungus associated with lesions was characterized as Conidiophores existing in single or in clusters, straight or flexuous, unbranched, percurrent, cylindrical, pale to dark brown.

Other Pests

Snails and Slugs. Few species of snail such as Giant snail (*Lissachatina fulica*) and slugs have also been found to affect the vegetative part of *Gynura* (Figure 8). They usually feed on decomposing vegetation however, when they were introduced to a new environment, they feed on a wide range of plants. All stages of plant development are eaten, leading to severe damage in those species that are most often attacked (Figure 9). However, cuttings and seedlings are the preferred source of food items, even of plants.

FUTURE PROSPECTS OF *Gynura*

Figure 8. Giant snail (*Lissachatina fulica*)

Figure 9. Plant condition attacked by Giant snail

procumbens

Gynura species are among the most important and thoroughly investigated plants with many applications in the food and pharmaceutical industries. In Malaysia, *G. procumbens*, which were recently listed under Agriculture NKEA under the Entry Point Project of Agriculture by the Malaysian Government have received particular attention in the pharmacological industry as an antidiabetic medicinal plant. Currently this herb is found growing naturally in the secondary forests. When there are demands, the indigenous people will search for *G. procumbens*, then collect and sun-dry them. After they are dried completely, the dried raw materials are sold to the buyers. In order to provide a regular and sustained supply of this plant materials, it is essential to domesticate and to develop a commercial cultivation method. A comprehensive understanding of their reproductive and growth physiology as well as ecological constraints, therefore, become necessary.

After completing the fundamental investigations on their physiological characteristics, one can embark on the commercialization of *G. procumbens*. Our local farmers should be educated with improved management practices for the production of *G. procumbens*. Therefore, there is critical need that the farmers should have adequate knowledge in the appropriate agronomic practices to maximize the yield and quality of this medicinal plant. Currently, little information is available on the cultivation of this medicinal plant. A manual of technical package of cultivation and post harvest technologies of *G. procumbens* is therefore of immediate need which may include in improving the quality of this herb.

CONCLUSION

In conclusion, based on current information, the middle part of stem from mother plants are suitable to be used as planting materials to be propagated and six weeks old rooted cutting are the most suitable to be transferred to the field for planting since it has high adaptability and stable to adapt with the new environment. While the mixture of peat moss and sand (1:3) is the most suitable growing media for propagation process. Chicken manure as a source of organic fertilizer is suggested to be applied with a rate of 300 kg N/ha. Whereas the information on the valuable phythochemical contents of *G. procumbens* shows that this herbal plant has a bright future to be planted commercially and chosen as a new source of

beneficial compounds which are very useful to be used in pharmaceutical industry.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Ministry of Agriculture and Agro- Based Industry for funding the research under NKEA Research Grant Scheme (NRGS) (Project number: NH1015A025).

REFERENCES

Akowuah, G. A., Sadikun, A., & Mariam, A. (2002). Flavonoid identification and hypoglycaemic studies of the butanol fraction from *Gynura procumbens*. *Pharmaceutical Biology*, *40*(6), 405-410. doi: 10.1076/phbi.40.6.405.8440

Alsarhan, A., Sultana, N., Al-Khatib, A., & Kadir, M. R. A. (2014). Review on some Malaysian traditional medicinal plants with therapeutic properties. *Journal of Basic and Applied Sciences*, *10*, 149-159. doi: 10.6000/1927-5129.2014.10.20

Arora, A., Nair, M. G., & Strasburg, G. M. (1998). Structure-activity relationships for antioxidant activities of a series of flavonoids in a liposomal system. *Free Radical Biology and Medicine*, *24*(9), 1355- 1363. doi: 10.1016/S0891-5849(97)00458-9

Boch, J., & Bonas, U. (2010). *Xanthomonas* AvrBs3 family-type III effectors: Discovery and function. *Annual Review of Phytopathology*, *48*(1), 419–36. doi: 10.1146/annurev-phyto-080508-081936.

Bohmfalk, G. T., Frisbie, R. E., Sterling, W. L., Metzer, R. B., & Knutson, A. E. (2011). *Identification, biology, and sampling of cotton insects*. Retrieved July 20, 2018, from http:// www.soilcropandmore.info/crops/CottonInformation/insect/B-933/b933.htm

Bonini, M., Maringoni, A. C., & Neto, J. R. (2007). Characterization of *Xanthomonas* spp. strains by bacteriocins. *Summa Phytopathologica*, *33*(1), 24-29. doi:10.1590/S0100-54052007000100003

Bukhori, M. F., Jaafar, H. Z. E., & Ghasezamdeh, A. (2015). Watering and nitrogen and potassium fertilization: The significance of abiotic control on *Gynura procumbens* (Lour.) Merr. herbs in Malaysia for better growth and secondary enrichment. *Asia-Pacific Journal of Molecular Biology and Biotechnology*, *23*(2), 303-313. doi: 10.21307/apjmbb-2015-010

Burr, T. J., & Schroth, M. N. (1977). Occurrence of soft-rot *Erwinia* spp. in soil and plant material. *Phytopathology*, *67*(11), 1382-1387. doi: 10.1094/Phyto-67-1382

Cho, J. D., Kim, J. S., Lee, S. H., Choi, G. S., & Chung, B. N. (2007). Viruses and symptoms on peppers and their infection types in Korea. *Research in Plant Disease*, *13*(2), 75−81. doi: 10.5423/RPD.2007.13.2.075

Choi, H. S., Cho, J. D., Lee, K. H., & Kim, J. S. (2001). Broad bean wilt fabaviruses and their specific ultrastructures. *Korean Journal of Electron Microscopy*, *31*(3), 215−222.

Echandi, E., & Moyer, J. W. (1979). Production, properties, andmorphology of bacteriocins from *Erwinia chrysanthemi*. *Phytopathology*, *69*(11), 1204-1207. doi: 10.1094/Phyto-69-1204.

Flint, M. L. (1998). *Pests of the garden and small farm: A grower's guide to using less pesticide* (2nd ed.). Oakland, USA: University of California Division of Agriculture and Natural Resources.

Galati, G., & O' Brien, P. J. (2004). Potential toxicity of flavonoids and other dietary phenolics: Significance for their chemopreventive and anticancer properties. *Free Radical Biology and Medicine*, *37*(3), 287- 303. doi: 10.1016/j.freeradbiomed.2004.04.034

Global Information Hub on Integrated Medicine. (n.d.-a). *Gynura procumbens (Lour.) Merr.* Retrieved July 15, 2018, from http://www.globinmed.com/index.php?option=com_content&view=%20article&id=62750:gynura-procumbens-lour

Global Information Hub on Integrated Medicine. (n.d.-b). *Sambung Nyawa*. Retrieved July 27, 2018, from http://www.globinmed.com/ index.php?option=com_content&view=article&id=104425:sambung-nyawa104425&catid=123&Itemid=132

Havsteen, B. H. (2002). The biochemistry and medical significance of the flavonoids. *Pharmacology and Therapeutics*, *96*(2-3), 67-202. doi: 10.1016/S0163-7258(02)00298-X

Hew, C. S., & Gam, L. H. (2011). Proteome analysis of abundant proteins extracted from the leaf of *Gynura procumbens* (Lour.) Merr. *Applied Biochemistry and Biotechnology*, *165*(7-8), 1577–1586. doi: 10.1007/s12010-011-9377-x

James, B., Atcha-Ahowé, C., Godonou, I., Baimey, H., Goergen, H., Sikirou, R., & Toko, M. (2010). *Integrated pest management in vegetable production: A guide for extension workers in West Africa*. Retrieved August 1, 2018, from https://cgspace.cgiar.org/ handle/10568/63650

Kaewseejan, N., & Siriamornpun, S. (2015). Bioactive components and properties of ethanolic extract and its fractions from *Gynura procumbens* leaves. *Industrial Crops and Products*, *74*, 271-278. doi: 10.1016/j.indcrop.2015.05.019

Kaewseejan, N., Puangpronpitag, D., & Nakornrian, M. (2012). Evaluation of phytochemical composition and antibacterial property of *Gynura procumbens* extract. *Asian Journal of Plant Sciences*, *11*(2), 77-82. doi: 10.3923/ajps.2012.77.82

Keng, C. L., Yee, L. S., & Pin, P. L. (2009). Micropropagation of *Gynura procumbens* (Lour.) Merr. an important medicinal plant. *Journal of Medicinal Plants Research*, *3*(3), 105-111.

Lee, U., Hong, J. S., Choi, J. K., Kim, K. C., Kim, Y. S., Curtis, I. S., Lim, P. O. (2000). Broad bean wilt virus causes necrotic symptoms and generates defective RNAs in *Capsicum annuum*. *Phytopathology*, *90*(12), 1390−1395. doi: 10.1094/PHYTO.2000.90.12.1390

Lila, M. A. (2004). Anthocyanins and human health: An *in vitro* investigative approach. *Journal of Biomedicine and Biotechnology*, *2004*(5), 306-313. doi: 10.1155/S111072430440401X

Ministry of Agriculture and Agoro-Based Industry. (2018). *NKEA agriculture sector.* Retrieved July 10, 2018, from http://www.moa.gov.my/nkea-sektor- pertanian

Mou, K. M., & Dash, P. R. (2016). A comprehensive review on *Gynura procumbens*. *International Journal of Pharmacognosy*, *3*(4), 167-174. doi: 10.3389/fphar.2016.00052

Murakami, M., Tsuda, K., & Kusigemati, K. (2000). Biological studies of the pests feeding on *Gynura bicolor* (Willd.) DC. (Asteraceae) II. List of feeding species, seasonal abundance and damage-occurrence in Kagoshima Prefecture in 1998. *Bulletin of the Faculty of Agriculture, Kagoshima University*, (50), 9-39.

Nagarajan, S., & Nagarajan, S. (2009). Abiotic tolerance and crop improvement. In A. Pareek, S. K. Sopory, H. J. Bohnert, & Govindjee (Eds.). *Abiotic stress adaptation in plants* (pp. 1-11). Dordrecht, Netherlands: Springer.

Nasir, N. N. N. M., Khandaker, M. M., & Mat, N. (2015). Bioactive compound and therapeutic value of the some Malaysia medicinal plants: A review. *Journal of Agronomy*, *14*(4), 319-330. doi: 10.3923/ja.2015.319.330

Perry, L. M. (Ed.). (1980). *Medicinal plants of East and Southeast Asia: Attributed properties and uses*. Cambridge, USA: The MIT Press.

Rahman, A. F. M. M., & Asad, M. S. A. (2013). Chemical and biological investigations of the leaves of *Gynura procumbens*. *International Journal of Biosciences*, *3*(4), 36-43. doi: 10.12692/ijb/3.4.36-43

Rohin, M. A. K., Jumli, M. N., Ridzwan, N., Baig, A. A., Latif, A. Z. A., & Hadi, N. A. (2018). Effect of *Gynura procumbens* extracts on anti- proliferative activity and its associated morphological changes of human *Glioblastoma multiforme* cell line (U-87). *Pharmacognosy Journal*, *10*(3), 492-496. doi: 10.5530/pj.2018.3.81

Rosidah, Yam, M. F., Sadikun, A., & Asmawi, M. Z. (2008). Antioxidant potential of *Gynura procumbens*. *Pharmaceutical Biology*, *46*(9), 616-625. doi: 10.1080/13880200802179642

Shafaei, A., Muslim, N. S., Nassar, Z. D., Aisha, A. F. A., Majid, A. M. S. A., & Ismail, Z. (2014). Antiangiogenic effect of *Ficus deltoidea* Jack standardised leaf extracts. *Tropical Journal of Pharmaceutical Research*, *13*(5), 761-768. doi: 10.4314/tjpr.v13i5.16

Shen, Y. M., Chao, C. H., & Liu, H. L. (2011). First report of *Phytophthora drechsleri* associated with stem and foliar blight of *Gynura bicolor* in Taiwan. *Plant Disease*, *95*(7), 874-874. doi: 10.1094/PDIS-12-10- 0931

Strickland, A. H. (1969). *Plant protection and world crop production*, by H. H. Cramer Leverkusen: 'Bayer' Pflanzenschutz (1967), pp. 524. *Experimental Agriculture*, *5*(1), 82-83. doi:10.1017/S0014479700010036

Sukadeetad, K., Nakbanpote, W., Heinrich, M., & Nuengchamning, N. (2018). Effect of drying methods and solvent extraction on the phenolic compounds of *Gynura pseudochina* (L.) DC. leaf extracts and their anti-psoriatic property. *Industrial Crops and Products*, *120,* 34-46. doi: 10.1016/j.indcrop.2018.04.020

Tan, H, L., Chan, K. G., Pusparajah, P., Lee, L. H., & Goh, B. H. (2016). *Gynura procumbens*: An overview of the biological activities. *Frontiers in Pharmacology*, *7*(52), 1-14. doi: 10.3389/fphar.2016.00052.

Taylor, R. H., & Stubbs, L. L. (1972). Broad bean wilt virus. *Description of plant viruses* (Volume 20, pp. 81). Warwick, England: Commonwealth Agricultural Bureaux and the Association of Applied Biologists, 1970.

Tudor-Nelson, S. M., Minsavage, G. V., Stall, R. E., & Jones, J. B. (2003). Bacteriocin-like substances from tomato race 3 strains of *Xanthomonas campestris* pv. *vesicatoria*. *Phytopathology*, *93*(11), 1415-1421. doi: 10.1094/PHYTO.2003.93.11.1415

Vanijajiva, O. (2009). The genus *Gynura* (Asteraceae: Senecioneae) in *Thailand*. *Thai Journal of Botany*, *1*(1), 25-36.

Verma, A. K., Singh, H., Satyanarayana, M., Srivastava, S. P., Tiwari, P., Singh, A. B., & Pratap, R. (2012). Flavone-based novel antidiabetic and antidyslipidemic agents. *Journal of Medicinal Chemistry*, *55*(10), 4551-4567. doi: 10.1021/jm201107g

Wiart, C. (2002). *Medicinal plants of Southeast Asia* (2nd ed.). Petaling Jaya, Malaysia: Prentice Hall.

Zahra, A. A., Kadir, F. A., Mahmood, A. A., Al Hadi, A. A., Suzy, S. M., Sabri, S. Z., & Ketuly, K. A. (2011). Acute toxicity study and wound healing potential of *Gynura procumbens* leaf extract in rats. *Journal of Medicinal Plants Research*, *5*(12), 2551-2558.