Current Scenario on the Prevalence of Diseases in Economically Important Medicinal and Aromatic Crops of Tamil Nadu

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ABSTRACT

A roving survey for disease assessment was performed in major medicinal plants growing areas of Tamil Nadu during the period from April 2018 to March 2019. The observations indicated that root rot caused by Macrophomina phaseolina recorded maximum disease incidence even up to 16.5 to 35 % in Coleus forskohlii at Tiruchengode, Perundurai and Nambyur villages. The Macrophomina root rot and Meloidogyne root knot nematode complex was also recorded up to 2 per cent. Recently, the M. phaseolina has expanded its host range to the medicinal crop Andrographis paniculata as recorded at Coimbatore with incidence up to 30%. In Gloriosa superba, severe incidence of root rot caused by M. phaseolina and tuber rot caused Sclerotium rolfsii act as a threat to cultivation with incidence ranging from 8 to 23 % and 8.5 to 25 % in Ambilikai, Mulanur, Kallimandhayam, Dharapurum and Nallamplaaum villages. In these areas, the crop also suffers loss due to leaf blight caused by Alternaria alternata up to 14.6 PDI. Recently, symptoms with chlorotic striations in leaves, stunted growth and reduced flower set with malformed pods were observed due to incidence virus in G. superba. The drought resistant crop Cassia angustifolia also suffers severe yield loss due to Macrophomina root rot and Alternaria leaf blight. Recently, phytoplasmal incidence was now noticed in Solanum trilobatum with incidence up to 9% as in Catharanthus roseus (20 % incidence). The Solanum nigrum also suffers yield loss due to Alternaria leaf blight (11.5 PDI) and rust incidence (12.5 PDI). The aromatic crop Cymbopogon martini is also affected by rust caused by Puccinia nakanishiki up to 9.8 PDI. Leaf blight caused by Helminthosporium sp. is prevalent in Chrysopogon zizanoides and C. martini with incidence up to 9.5 PDI. Other diseases of minor medicinal and aromatic crops are also discussed.

Keywords: Medicinal plants, Diseases, Incidence, Root rot, Leaf blight

INTRODUCTION

Globally there is a great demand for Medicinal and Aromatic crops in the international market for health products, pharmaceuticals, food supplements, cosmetics etc. The international market of medicinal plants is expected to reach USD 35.4 billion by 2020 with a compound annual growth rate of 6.6% from 2015 to 2020 as mentioned in BCC research report (Yadav, 2019).

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The varied agroclimatic conditions of India offer scope for cultivation of wide range of medicinal plants that made it as one major exporter of crude drugs mainly to six developed countries viz. USA, Germany, France, Switzerland, U.K. and Japan that shares 75-80 per cent of the total export market (Chatterjee, 2002). Nearly 90% of the medicinal plants used by local communities in India are sourced from the wild. Among these about 335 medicinal plant species are recognised as threatened at the regional, national and global levels (Shankar, 2019).

**Coleus forskohlii** Briq. is cultivated in more than 1000 hectares across Salem, Attur, Kallakurichi, Thiruvannamalai, Trichy and Vellore regions (Rajamani et al., 1999) and the seeds are exported for forskohlin content. In the last decade due to changing climate scenario lot of pests and diseases found infecting the agricultural and horticultural crops have moved to the medicinal and aromatic crops also. Those diseases which were of minor importance in the recent past has now become a threat to cultivation of medicinal crops in India. The medicinal and aromatic crops viz., *Gloriosa superba*, *Coleus forskohlii*, *Cassia angustifolia*, *Vetiver zizanoides*, *Andrographis paniculata*, *Catharanthus roseus*, *Ocimum sanctum*, *Solanum nigrum* is cultivated by farmers in Tamil Nadu. Apart from this based on the consumers need and demands of the local markets the medicinal crops such as *Aloe vera*, *Solanum trilobatum*, *Plumbago zeylanica*, *Aegle marmelos*, *Gynnema sylvestre*, *Cymbopogon flexuosus*, *Cymbopogon martini* and *Phyllanthus niruri* are being cultivated locally by farmers themselves and finds usage in preparation of plant based medicines as home remedies against many human ailments like common flu, cold, fever, acidity problems, sinusitis and as immunity builder. Perusal of literature shows very few reports of diseases in medicinal crops like *Gloriosa superba*, *Coleus forskohlii* and *Cassia angustifolia*. In the recent days, many foliar diseases caused by *Alternaria*, *Curvularia*, *Colletotrichum*, stem rot and root rot caused by *Fusarium* sp. in *Gloriosa superba* and fungal nematode root rot complex prevalent in *Coleus forskohlii* which is left unnoticed.

Perusal of literature showed reports of diseases of few crops (Singh et al., 2016; Marimuthu et al., 2018) However, there is no pertinent information of progression of diseases in the past one decade due to climate change and changing cultivation patterns. Farmers are facing threat to cultivation of *Gloriosa superba*, *Coleus forskohlii*, *Cassia angustifolia* mainly due to the complex soil borne diseases and emerging new diseases and experience severe yield loss as they are not aware of the spread of the pathogen. Hence, a study was planned with a view to document and monitor the incidence of all the diseases affecting the major medicinal and aromatic crops cultivated in Tamil Nadu during the period from April,2018 to March 2019 so as to establish a scenario of disease prevalence in Tamil Nadu.

**MATERIALS AND METHODS**

A roving survey was carried out on the occurrence of diseases of important medicinal and aromatic plants during the period from April, 2018-March, 2019 at famer field. About 4-5 fields were covered in a district which include two or three villages where the medicinal crops are cultivated on commercial scale. Simultaneously, the diseases occurring in medicinal plants at the medicinal plant garden of Department of Medicinal and Aromatic Crops, Tamil Nadu Agricultural University, Coimbatore was documented and the diseases incidence was recorded. For foliar diseases, the 0 to 9 scale was followed and the diseases incidence was expressed as Per cent disease Index (PDI) (Pawlec et al., 2006). The soil borne disease like root rot and wilt were expressed as percentage (%) of infected plants.

**RESULTS AND DISCUSSION**

Data provided in Table 1 gives picture on the incidence of various diseases affecting economically important medicinal crops. The varying disease incidence and the field
observations are discussed in detail for the benefit of the researchers and farming community (Plate 1). The observations showed that at Tiruchengode in about 3-4 fields of Coleus forskohlii Briq. (under drip irrigation) exhibited severe root rot incidence caused by Macrophomina phaseolina up to 35 per cent along with 2 per cent infestation by root rot and root knot nematode complex. The plants were at 45 days stage where there was extensive spread of the disease in patches. Initially infected plants were identified as wilted and pale green whereas severely infected plants showed complete wilting with yellow leaves and the decayed roots were totally black in colour with fungal invasion. The plants could be easily pulled with infected roots remaining in soil. Few plants (2 per cent) exhibited root rot and part of the roots were with knots showing symptoms of root rot nematode Meloidogyne infestation. Similarly, Macrophomina root rot with 20%, 16.5% and 5% was observed at plants (40 days) in Perundurai, Nambiyur and Coimbatore. But in Attur, Nambiyur and Tiruvannamalai areas, the collar rot (Fusarium chlamydosporum) along with root knot nematode Meloidogyne infestation was recorded to be ranging from 12-25 per cent under irrigated conditions. Here the plants exhibited wilting symptoms and the collar region was fully decayed and the plants were found to be collapsed and could be pulled out. The roots when given longitudinal split showed pinkish discoulourtion. Reports of the Macrophomina root rot (Kamalakannan et al., 2006) of C. forskohlii with 50% yield loss (Meena, 2016) has been mentioned by few researchers as in our study. Also the root knot infestation by Meloidogyne spp has been reported to cause 86% yield loss in association with M. phaseolina infection (Bhandari et al., 2007, Senthammarai et al., 2006 and 2008) but in our study only 2% infestation was noticed in combination with root rot. Apart from this leaf spot due to Corynespora cassicola with pale brown to dark brown spots which causes necrosis of leaves have been reported (Fernandes and Barreto, 2003) as in our study recorded at Perundurai with 10.5 PDI. But another leaf spot caused by Botryodiplodia theobromae (Rakshapal Singh et al., 2011) was not noticed in our survey.

From the observations it is discussed here that farmers need to take utmost care to contain the disease spread by spotting one or two plants with symptoms of root rot/ collar rot incidence at initial stages itself from 30 days after planting since there after the disease management becomes complicated as the crop canopy covers the entire field and it is not easy to apply the biocontrol agents or fungicides.

The Gloriosa superba L. (Glory lily) crop is well known for its medicinal importance due to the presence of alkaloid colchicine used in the treatment of gout (Padmapriya et al., 2016). This crop suffers from soil borne diseases viz., Macrophomina root rot, tuber rot caused by Sclerotium rolfsii and leaf blight diseases caused by Alternaria alternata and Colletotrichum gloeosporioides in Tirupur and Dindugul districts where this crop is cultivated on a large scale. Root rot caused by Macrophomina phaseolina incidence has been recorded from 8.5 to 25% in Mulanur, Ambilikai and Dharapurum areas but lower disease incidence only up to 5.5% was recorded in Sirumugai. The crop is affected with this disease by exhibiting symptoms of sudden drying of the plant and the plant gets detached from the root portion. Tubers from infected plants when observed revealed decaying with black fungal invasion on the tubers. The tuber rot caused by Sclerotium rolfsii is another interesting pathogen that attack the plants at collar region as seen with whitish mycelial strands over the soil and the pathogen moves deep in to the soil and colonises the tuber and produces about 50 to 100 sclerotia per tuber. The disease spread is fast in the field with wilting and yellowing of leaves and finally the plant collapses as observed in Nallampalayam, Dharapurum, Kallimandhayam and Mulanur with incidence ranging from 8 to 23 per cent. Both the Macrophomina root rot and Sclerotium tuber rot is soil borne and tuber borne under storage. Tuber rot is more prevalent in red loamy soils compared to other soils.
The leaf blight in *G. superba* is caused by two pathogens that can be well differentiated by the symptoms. *Alternaria* leaf blight produces blackish lesions on the leaves that enlarges and causes severe blighting of leaves with incidence ranging from 12.5 to 14.6 as recorded in the areas surveyed. Leaf blight due to *Colletotrichum gloeosporioides* was observed with 18.5 PDI only in Dharapurum with typical oval shaped spots that enlarge and covers the entire leaf with production of prominent acervuli at the whitish centre of the blighted areas. These foliar pathogens *Alternaria* and *Colletotrichum* harbouring the weed plants nearby *Gloriosa* fields would be the reason for their incidence under favourable conditions of high humidity (70 %) and rainfall during flowering periods. Similar symptoms and the incidence due to *A. alternata* was reported by Maiti et al. (2007).

Further it is noticed that the *Altenaria* blight caused drying of flowers and later the pods on infected plants showed large blighted lesions causing necrosis of outer surface of pods. Though few pods were infected, the infection did not progress in to the seeds. During the peak periods of high humidity coupled with warm weather immediately one after planting tubers (month of September) few plants exhibited stunted growth coupled with striations son the leaves resembling stripe virus symptoms (2 to 15 %) at Coimbatore, Mulanur and Dharapurum. Those plants were found to be harboured by aphids which would have migrated from weed plants. There was no tuber transmission of virus; however it is suspected that insects aid as vector for spread of the virus. Infected plants produced 25 % less flowers and malformed and twisted pods than normal healthy plant. Studies should be further concentrated on the virus vector relationship to take up management practices.

The *Cassia angustifolia* L. (Senna) well known for presence of sennosides are used as laxatives (Janaesha et al., 2018). The crop suffers from root rot incidence up to 10 % in Coimbatore, Thirumanagalam, Virudhunagar and Pannikundu especially during periods of rain immediately after a dry spell. Also the leaf blight caused by *Alternaria alternata* is another problem that cause severe defoliation of leaves (10.6 to 12.5 PDI) during October to December coinciding with rainfall and low temperature. Similar severe yield reduction even up to 30 per cent were reported (Patel and Pillai, 1979; Maiti et al., 2007). Similarly *Andrographis paniculata* (Kalamegh) Burm. F Nees known for the alkaloid andrographolide is used against stomach pains, fever, respiratory diseases and as antidote for poisonous stings (Jarukamjorn, 2010) was found to be a new host for root rot pathogen *Macrophomina phaseolina* which recorded 30 per cent root rot incidence at Coimbatore.

Sudden drying of the plants leads to death of the plants within 10 days of incidence with noticeable decaying and splitting of roots. The pathogen was isolated and further inoculation of pathogen under pot culture study proved Kochs postulates and reproduced similar symptoms of root rot.

* Catharanthus roseus* (Perwiwinkle) has cytotoxic dimeric alkaloids vinblastine and vincristine widely used for cancer chemotherapy (Van der Heijden, 2004) is affected by phytoplasmal disease (Singh et al., 2007). In our study also chlorosis and bunching of leaves, shortened internodes and phyllloid flowers due to phytoplasma infection (20 %) was noticed at Coimbatore. Similarly the *Solatnum trilobatum* L. crop also encountered phytoplasmal infection (9%) at Coimbatore with crowding, reduction in size of leaves similar to the symptoms described by Thiribhuvanamala et al. (2018) *Alternaria* spp. caused leaf blighting in *S. trilobatum* and *Solanum nigrum* L. (Black night shade) with incidence of 10.8 to 11.0 PDI. Rust disease with light yellow spots on upper surface with light orange to brown pustules on lower leaf surface was noticed during September months at coimbatore with disease incidence of 12.5 PDI which coincided with high humidity (70 %) and warm weather (36 to 38°C). The aromatic crop *Cymbopogon martini* recorded leaf blight incidence due to *Helminthosporium* sp. with disease incidence of 10.3 PDI. Also severe rust incidence (*Puccinia nakanishiki*) with 12.5 PDI was recorded in *C. martini* coinciding with high humidity and warm
weather during August to September months. *Chrysopogon zizanoides* (vetiver) also recorded leaf blight due to *Helminthosporium* sp. with disease incidence of 9.0 PDI.

Other minor diseases mainly the foliar diseases caused by *Alternaria*, *Colletotrichum*, *Cercospora* sp., and powdery mildew were recorded at Coimbatore conditions in *Aegle mamekos*, *Aloe vera*, *Cissu squadrangularis*, *Coleus aromaticus*, *Gymmnema sylvestre*, *Lipia nodiflora*, *Plubago zeylanica*, *Phyllanthus niruri*, *Psoralea corylifolia*, *Rosemarinus officinalis*, and *Salacia oblonga* (Table 2).

Table 1: Survey and documentation of major diseases in medicinal and aromatic crops (April 2018-March 2019)

| S.No | Name of the Crop | Disease/ Pathogen | Place | GPS coordinates | District | Incidence (%) or PDI |
|------|------------------|-------------------|-------|-----------------|---------|----------------------|
| 1.   | *Coleus forskohlii* | Root rot *M. phaseolina* | Tiruchengode | 11.3884°N 77.9707°E | Namakkal | 12- 35% |
|      |                   | Root rot (M. phaseolina) and nematode complex (Meloidogyne incognita) | Perundurai | 11.2590°N 77.5460°E | Erode | 20.5% |
|      |                   | Root rot *M. phaseolina* | Nambiyur | 11.3614°N 77.3501°E | Erode | 16.5% |
|      |                   | Collar rot *Fusarium chlamydosporium* | Nambiyur | 11.3614°N 77.3501°E | Erode | 17- 20% |
|      |                   | Collar rot *Fusarium chlamydosporium* sp. and root knot nematode complex | Attur | 11.5965°N 78.6033°E | Salem | 12-25% |
|      |                   | Root rot *M. phaseolina* | Coimbatore | 11.0123°N 76.9355°E | Coimbatore | 5% |
|      |                   | Leaf spot *Corynespora cassicola* | Perundurai | 11.2590°N 77.5460°E | Erode | 10.5 PDI |
| 2    | *Gloriosa superba* | Root rot *M. phaseolina* | Mulanur | 10.7947°N 77.7111°E | Tirupur | 10.5% |
|      |                   | Ambilikai | 10.5475°N 77.7257°E | Dindugul | 8.5% |
|      |                   | Dharapuram | 10.7273°N 77.6710°E | Tirupur | 25% |
|      |                   | Sirumugai | 11.3216°N 77.0089°E | Coimbatore | 5.5% |
|      |                   | Tuber rot *Sclerotium rolfsii* | Nallampalayam | 10.7342°N 77.6288°E | Tirupur | 18% |
|      |                   | Dharapurum | 10.7273°N 77.6710°E | Tirupur | 8-23% |
|      |                   | Kallimandhaya m | 10.5912°N 77.6864°E | Dindugul | 16% |
|      |                   | Mulanur | 10.7947°N 77.7111°E | Tirupur | 9.5% |
|      |                   | Ambilikai | 10.5475°N 77.7257°E | Dindugul | 15.5% |
|      |                   | Leaf blight *Alternaria alternata* | Dharapuram | 10.7273°N 77.6710°E | Tirupur | 14.6 PDI |
|      |                   | Nallampalayam | 10.7342°N 77.6288°E | Tirupur | 12.7 PDI |
|      |                   | Kallimandhaya m | 10.5912°N 77.6864°E | Dindugul | 14.5 PDI |
|      |                   | Coimbatore | 11.0123°N 76.9355°E | Coimbatore | 12.5 PDI |
|      |                   | Sirumugai | 11.3216°N 77.0089°E | Coimbatore | 13.8 PDI |
|      |                   | Flower blight *Alternaria alternata* | Coimbatore | 11.0123°N 76.9355°E | Coimbatore | 4% |
|      |                   | Sirumugai | 11.3216°N 77.0089°E | Coimbatore | 8.5% |
| S.No. | Name of the Crop          | Disease                                      | Description                                                                 |
|-------|---------------------------|----------------------------------------------|----------------------------------------------------------------------------|
| 1.    | Aegle marmelos            | Powdery mildew (Erysiphe sp.)                | White powdery growth occurs on the upper surface of the leaves.             |
| 2.    | Aloe vera                  | Basal rot (Fusarium sp.)                     | Rottenning at the base of the stem and leaves.                             |
|       |                            | Leaf spot                                   | Irregular brown spots appear on the leaves with dark margin and light coloured centre. |
| 3.    | Cissus quadrangularis      | Leaf spot                                   | Dark brown oval spots appear on the leaves.                                |
|       | Coleus aromaticus          | Leaf spot                                   | Small, circular brown spots appear on the leaves.                          |
| 4.    | Gymnema sylvestre          | Leaf spot                                   | Brown oval spots with dark margin and light coloured centre appear on the leaves. |
| 5.    | Lipia nodiflora            | Leaf spot                                   | Small dark brown spots with concentric ring and yellow halo.               |
| 6.    | Plumbago zeylanica         | Leaf spot                                   | Irregular brown spots appear on the leaves with dark margin and light coloured centre. |
|       |                            | Root rot (Macrophomina phaseolina)           | Drying of twigs from the base. The field gives scorched appearance.        |

| S.No. | Name of the Crop          | Disease                                      | Description                                                                 |
|-------|---------------------------|----------------------------------------------|----------------------------------------------------------------------------|
| 3.    | Cassia angustifolia       | Root rot (M. phaseolina)                     |                                                                             |
|       |                            | Leaf blight (Alternaria alternata)           |                                                                            |
| 4.    | Andrographis paniculata   | Root rot (M. phaseolina)                     |                                                                            |
| 5.    | Catharanthus roseus       | Phytoplasma                                  |                                                                            |
| 6.    | Solanum trilobatum        | Phytoplasma                                  |                                                                            |
|       |                            | Leaf blight (Alternaria solani)              |                                                                            |
| 7.    | Solanum nigrum            | Leaf blight (Alternaria solani)              |                                                                            |
|       |                            | Rust (Puccinia sp.)                          |                                                                            |
| 8.    | Cymbopogon martinii       | Leaf blight (Helminthosporium sp.)          |                                                                            |
|       |                            | Rust (Puccinia nakanishikii)                 |                                                                            |
| 9.    | Chrysopogon zizanoides    | Leaf blight (Helminthosporium sp.)          |                                                                            |
|       |                            | Root rot (Macrophomina phaseolina)           |                                                                            |
Plate 1: Symptoms of major diseases of medicinal and aromatic crops

| No. | Crop Name | Disease Type | Description |
|-----|-----------|--------------|-------------|
| 9   | *Phyllanthus niruri* | Root knot nematode (Meloidogyne incognita) | Rotting of roots with presence of large sized galls or knots on the roots. |
| 9   | *Psoralea corylifolia* | Powdery mildew (*Oidium* sp.) | Whitish powdery patches on leaves and stem |
| 10  | *Rosenmarinus officinalis* | Powdery mildew (*Erysiphe* sp.) | White powdery growth occurs on the upper surface of the leaves. |
| 11  | *Salacia oblonga* | Root rot infected tubers of Glory Lily | Drying of plants with root disintegration |

- **Alternaria leaf blight of Glory lily**
- **Alternaria pod blight of Glory lily**
- **Tuber rot infected tubers in field**
- **Virus disease of Glory Lily**
- **Phytoplasma disease of *Solanum trilobatum***
- **Alternaria disease of Black night shade**
- **Powdery mildew of *Phyllanthus niruri***
- **Rust disease of *Cymopogon martini***
CONCLUSION
It is pertinent from the studies that the medicinal crops, Gloriosa superba, Coleus forskohlii and Cassia angustifolia is affected due to root rot caused by Macrophomina phaseolina. The tuber rot caused by Sclerotium rolfsii is another threat to Glory lily cultivation. The Coleus forskohlii crop is prone to root rot, collar rot and nematode infestation that leads to drastic yield reduction. The leaf blight caused by Alternaria and Colletotrichum also plays major role in defoliation of leaves that contribute to yield loss. These pathogens would thrive on weeds as alternate hosts so the the weeds around the crops have to be noticed and remove. The emerging virus and phytoplasma problems in Catharanthus roseus, Solanum trilobatum, G. superba has to be taken due care and further studies should be directed towards studying the virus vector relations ship . The farmers have to be given due awareness on the type of symptoms and the spread and survival of the pathogen to mitigate the disease incidence and yield loss. Certainly this study will throw light on the disease scenario of medicinal plants under Tamil Nadu conditions that help to monitor the diseases to avoid higher incidences and to take up integrated management practices to sustain the quality yield of medicinal crops.

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REFERENCES
Bhandari, S., Harsh, N.S.K., & Singh, P. (2007). First report of Meloidogyne arenaria on Coleus forskohlii in India Ind. Forester, 133, 1709-1710.
Chatterjee, S.K. (2002). Cultivation of medicinal and aromatic plants in India - a commercial approach. Acta Hortic., 576, 191-202.
Fernandes, R.C., & Barreto, R.W. (2003). Corynespora cassicola causing leaf spots on Coleus barbatus. Plant Patho., 52, 786
Jarukamjorn, K., Kondo, S., Chatuphonprasert, W., Sakuma, T., Kawasaki, Y., & Emito, N. (2010). Gender-associated modulation of inducible CYP1A1 expression by andrographolide in mouse liver. Eur J Pharm Sci ., 39, 394-401.
Jnanesha, A.C., Ashish Kumar, Vanitha T.K., & Deepak Kumar Verma. (2018). Opportunities and challenges in the cultivation of senna (Cassia angustifolia (Vahl.) International Journal of Herbal Medicine ., 6(4), 41-43
Kamalakannan, A., Mohan, L., Valluvaparidasan, V., Mareeswari, P., & Karuppiah, R. (2006). First report of Macrophomina root rot (Macrophomina phaseolina) on medicinal coleus (Coleus forskohlii) in India Plant Pathology, 55(2), 302.
Maiti, C. K., Sen, S. Paul, A.K., & Acharya, K. (2007). Alternaria alternata causing leaf spot and leaf blight diseases of some cultivated medicinal plants of lower Gangetic plains of West Bengal. J. Mycopathol. Res. 45, 132-13.
Marimuthu, T., Suganthy, M., & Nakkeeran, S. (2018). Common Pests and Diseases of Medicinal Plants and Strategies to Manage Them In: New Age Herbals. (B. Singh, K. V. Peter (eds.) Springer Nature Singapore Pte Ltd., https://doi.org/10.1007/978-981-10-8291-7_14
Meena, B. (2018). Integrated disease management of root rot in Coleus forskohlii. World Journal of Pharmaceutical sciences, 5(3), 1312-1317
Padmapriya, S., Rajamani, K., & Sathiyanurthy, V. (2016). Glory Lily (Gloriosa superba L.) - A Review. International Journal of Current
Pharmaceutical Review and Res., 7(1), 43-49.

Patel, K., D., & Pillai, S.N. (1979). Effect of leaf spot disease on sennoside content in senna leaves. Indian Drugs. 17, 1-2.

Pawelec, A A., Dubourg, C., & Briard, M. (2006). Evaluation of carrot resistance to Alternaria leaf blight in controlled environments. Plant Pathology 55, 68-72

Rajamani, K., Kempuchetty, N., & Thamburaj, S. (1999). Medicinal plant cultivation. Agro India 5, 4-5.

Rakshapal, S., Surendera, P., Gangwar, Singh, D., Singh, R., Pandey, R., & Kalra, A. (2011). Medicinal Plants Coleus forskohlii Briq.: Disease and Management. Medicinal Plants, 3(1), 1-7

Senthamari, K., Poornima, K., & Subramanian, S. (2006). Pathogenicity of Meloidogyne incognita on Coleus forskohlii Briq. Ind. J Nematol., 36(1), 123-125.

Senthamari, K., Poornima, K., Subramanian, S., & Sudheer, J. (2008). Nematode-Fungal Disease Complex involving Meloidogyne incognita and Macrophomina phaseolina on Medicinal Coleus, Coleus forskohlii Briq. Ind. J Nematol., 38(1), 30-33.

Shankar, D. (2019). The FRLHT-TDU story of conservation and sustainable use of medicinal flora. Journal of Medicinal Plant Conservation, 25(1), 45-63.

Singh, A., Gupta, A., Saikia, S., Pant, A., & Pandey, R. (2016). Diseases of medicinal and aromatic crops, their biological impact and management. Plant Genetic resources, 13(4), 370-383.

Singh, S.K., Aminuddin, P., Srivastava, B.R., & Khan, J.A. (2007). Production of phytoplasma-free plants from yellow leaf diseased Catharanthus roseus L. (G.). Journal of Plant Diseases and Protection, 114(1), 2-5.

Thiribhuvanamala, G., Parthasarathy, S., Renukadevi, P., & Rajamani, K. (2018). Incidence of a Candidatus Phytoplasma Associated with Phyllody Disease of Solanum trilobatum. Int. J. Pure App. Biosci., 6(6), 319-323.

Van der Heijden, R., Jacobs, D.I., Snoeijer, W., Hallard, D., & Verpoorte, R. (2004). The Catharanthus alkaloids: pharmacognosy and biotechnology, Current Medicinal Chemistry, 11(5), 607–628.

Yadav, P. (2019). Trade in Medicinal and Aromatic plants of India: An overview. Traffic Newsletter, June issue, 47.