Journal of Applied Research on Medicinal and Aromatic Plants xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Applied Research on Medicinal and Aromatic Plants

journal homepage: www.elsevier.com/locate/jarmap

Management of pests and diseases of important tropical/subtropical medicinal and aromatic plants: A review

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ARTICLE INFO

Keywords:
Cultivation technologies
Diseases
Economics
Nematodes
Pests
Plant protection strategies

ABSTRACT

Medicinal plant parts are generally used in ayurvedic medicines and local decoction and other home-made preparations. Essential oils extracted from aromatic plants are used in perfumes and food industries. Healthy plant material is therefore essential for maintaining product quality. However, cultivation of both medicinal and aromatic plants is facing problems, the major being lack of production technology and unregulated marketing. Additionally, both quantity and quality of biomass are adversely affected by the damages caused by pests and diseases during plant development. Currently, leaf sap sucking pests (mealy bugs, aphids, thrips, mites), defoliators (leaf rollers/webbers, grasshopper, epilachna beetles), flower bud and flower feeding pests (bud worms, gall midges, thrips), fungal diseases (root rot, wilt, leaf spots, blight/anthracnose) and root-knot nematodes are common and important invaders during crop cultivation.

Synthetic insecticides particularly organophosphates, carbamates, pyrethroids and neonicotinoids have been extensively used by farmers for protecting medicinal and aromatic plants. Consequently, toxic residue of pesticides in raw material posed serious concerns of risk to human health. Therefore, an integrated management including cultural practices, plant-derived products and biological control has been experimented on limited scale. This review compiles scattered information on current control measures in 10 medicinal and 11 aromatic plants and discusses how the integrated measures can be applied to make crop cultivation profitable and eco-friendly. This strategy which is replicable in other medicinal and aromatic plants may have perspective by way of increasing demand for healthy plant material meant for sale in local market and for export.

1. Introduction

Medicinal and aromatic plants are cultivated or found in the wild round the year and are used for various purposes including traditional herbal remedy (infusion and decoction) in the developing and less developed countries (Kumar, 2014). Similarly, local treatments with cost-free plant material assures health security to poor people in rural areas (Trivedi, 2015). The medicinal and aromatic plants can support livelihood of poor families since they collect raw material from the wild and sell it in local markets. Besides, the phytochemicals are extracted from plant parts for homoeopathic and ayurvedic drugs, cosmetics, neutraceuticals/dietary supplements and functional foods (Nagpal and Karki, 2004; Yaniv and Bacharach, 2005). Extracts in water or alcohol of these plants are applied against pests and plant diseases due to their biological effects (Isman, 2000; Bakkali et al., 2008). Parts of aromatic plants with characteristic aroma are also used to extract aroma therapy oils/essential oils (EO) (Nagpal and Karki, 2004) which are major allelochemicals of economic value (Table 1).

The diversity of indigenous flora with over 6,000 species of medicinal plants has been reported from different tropical regions (Khare, 2008). From this natural treasure, over 1,000 plants are classified as aromatic (Panda, 2015). In fact, the medicinal plants and aromatic plants are not distinguished in the marketing chain (Lange, 2004) probably because these plants are often included in forest trees, ornamental plants, spices and condiments. For providing regular supply of plant biomass to various industries, commercial cultivation for large scale production of raw material is nowadays possible with improved practices (Panda, 2015). In fact, the industries engaged in pharmaceuticals, aroma chemicals, seasoning, fragrance and oil extraction are growing worldwide at 7–15% annually (Lange, 2004). To cope with the increasing market demand, crop productivity needs to be increased. Also, healthy plant material is essential for maintaining product quality. Currently, the supply of raw plant material is inadequate due to less crop production and often, is of inferior quality (Nagpal and Karki, 2004). The problems currently faced by farmers are associated with the cultivation practices. These include replenishment of quality planting

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https://doi.org/10.1016/j.jarmap.2018.03.002
Received 24 October 2017; Received in revised form 26 February 2018; Accepted 1 March 2018

Please cite this article as: Gahukar, R.T., Journal of Applied Research on Medicinal and Aromatic Plants (2018), https://doi.org/10.1016/j.jarmap.2018.03.002

Table 1
Compounds of the essential oil of important aromatic plants.

Plant[a]	Economic plant part	Aromatic allelochemicals/essential oils
Geranium	Flower	Citronellol, linalool, isomenthone, geranyl formate, citronellyl formate, geraniol
Jasmine	Flower	Benzyl acetate, terpinol, jasmone, benzyl benzoate, linalool
Lemon grass or Citronella grass	Leaf	Geraniol, geranyl acetate, limonene, myrcene
Mint	Leaf, whole plant	Menthol, methyl acetate, menthone, menthofuran, limone, pulegone
Palmarosa	Leaf	Linalool, geraniol, geranial, geranyl acetate
Patchouli	Leaf, whole plant	Pagionol, caryophyllon
Rose	Flower	Beta-damascone, beta-ionone, rose oxide, beta- damascenone
Rosemary	Leaves	Alpha-pinene, 1–8-cineole, camphor, bornyl acetate
Sandalwood	Heartwood	Santanol, santalene, beta-santol beta-santol sesquiterpenes
Vetiver	Root	Veliverone, velivrals, veliverna, zizanal, epizizanal

[a] Geranium = *Pelargonium* spp., Jasmine = *Jasminum* spp., Lemon grass, = *Cymbopogon winterlanus,* citronella grass = *Cymbopogon nardus,* Mint = *Mentha* spp., Palmarosa = *Cymbopogon martinii*, Patchouli = *Pogostemon cablin*, Rose = *Rosa* spp., Rosemary = *Rosamarinus officinalis*, Sandalwood = *Santalum* spp., Vetiver = *Vetiveria zizanioides*.

material of improved/recommended cultivars, over-exploitation of natural resources by harvesting in a destructive manner, no systematic cultivation mostly in small land holdings, long growing period for some plant species, misidentification of plant species leading to adulteration, indiscriminate collection from the wild, competition with wild populations, lack of facilities for plant identification and standardized package of practices suitable to different agro-ecological conditions (Chatterjee, 2002; Mittal and Singh, 2007),

Marketing of harvested biomass is a chronic and serious problem due to speculative trade with fluctuating market prices, wide variation in the quality specifications for the raw material, adulteration and mimics, and different methods of testing for allelochemicals and processing. After experiencing these problems particularly low prices than seasonal vegetables, farmers in Himalayan region have replaced medicinal plants by peas, potato and hops (Kala et al., 2006). Other field crops like sugarcane, paddy followed by wheat, paddy -mustard -vegetable pea gave higher profit than lemon grass, citronella grass and patchouli plants, but oils gave profitable returns (Mittal and Singh, 2007) (Table 2). In some instances, cultivation of aromatic plants however resulted in better economic returns than field crops (Kalaichelvi and Swaminathan, 2009) (Table 2). These data need further trials to convince the farmers of significant economic gain from the cultivation of medicinal and aromatic plants.

In India, the medicinal and aromatic plants are cultivated over 617,000 ha producing 1156,000 m t of biomass with a productivity of 1.9 t ha^{-1} (DA, 2017). Maximum area of 55,000 ha is under blond psyllium followed by 5,000 ha each under musli and Indian ginseng. The crop productivity differs considerably from region to region and year to year for each plant species. For example, the productivity of lemon grass, citronella grass and patchouli has been recorded in the order of 577,387 and 106 q ha^{-1}, respectively (Mittal and Singh, 2007) and that of serpentine, Indian ginseng, blond psyllium, aloe and holy basil was 6–10 kg seeds + 15–20 q roots ha^{-1}, 12–15 q roots ha^{-1}, 10–12 q seeds + 10–12 q roots ha^{-1}, 390–410 q ha^{-1} and 25–30 q ha^{-1}, respectively (Kalaichelvi and Swaminathan, 2009).

The structure of the global import market is mostly competitive. Therefore, export promotion strategies to markets with higher relative advantage have been recommended by Roosta et al. (2017). The global market for the medicinal and aromatic plants and their products is currently around US$ 62 billion and is expected to grow at 15% annually. India's share is about 2% estimated at US$ 4–5 billion (Singh and Vidyasagar, 2015) compared to USA and Europe where the trade has been growing at 10% per annum. The global demand estimated by WHO is about US$ 5 trillion by the year 2050 with increasing demand from the USA, Germany and France, and new markets including Argentina, Brazil, Mexico, China, Indonesia, Malaysia, Singapore and Japan (Kalaichelvi and Swaminathan, 2009; Roosta et al., 2017). India can earn US$ 76.9 million $year^{-1}$ by export which is currently 15% in terms of production of essential oils and a profit of US$ 1,190 ha^{-1} of land (Chatterjee, 2002; Singh and Vidyasagar, 2015). Most demanded plants for export from India include brahmi, Indian gooseberry, sandalwood, holy basil, asparagus and blond psyllium.

Changes in climate, adoption of intensive cultivation practices, and market-driven crop management for high yielding cultivars led to increase in attack of insects, mites, disease pathogens and nematodes. Their damage potential has increased in both intensity and frequency in various crops including medicinal and aromatic crops (Sharma, 2013; Sharma et al., 2014b). Moreover, some insects, mites, nematodes and disease pathogens attack one or more plant species in the same agroecosystem (Shukla et al., 2000; Parameswaran et al., 2000). The damages caused by pests or diseases can reduce productivity of biomass

Table 2
Comparative net profit from cultivation of certain medicinal and aromatic plants and field crops in India.

Crop	Net profit ha^{-1}		Reference
	Biomass	Oil	
A. Medicinal and aromatic plants[a]			
Lemon grass	US$ 274.92 (INR 17,320)	US$ 777.36 (INR 48,974)	(1)
Citronella grass	US$ 9.65 (INR 608)	US$ 725.38 (INR 45,699)	(1)
Patchouli	US$ 115.80 (INR 7,296)	US$ 409.85 (INR 25,821)	(1)
Palmarosa	US$ 547.61 (INR 34,500)		(2)
Vetiver	US$ 714.28 (INR 45,000) (2)		(2)
Indian ginseng	US$ 793.65 (INR 50,000)		(2)
B. Field crops			
Sugarcane	US$ 571.11 (INR 35,980)		(1)
Coarse paddy-wheat	US$ 252.47 (INR 15,906)		(1)
Fine paddy–mustard–vegetable pea	US$ 396.85 (INR 25,002)		(1)
Paddy	US$ 206.34 (INR 13,000)		(2)
Wheat	US$ 126.98 (INR 8,000)		(2)

Reference: (1) Mittal and Singh (2007), (2) Kalaichelvi and Swaminathan (2009).
Exchange calculated @ 1 US$ = 63 Indian rupees (INR).
[a] Lemon grass = *Cymbopogon winterlanus*, Citronella grass = *Cymbopogon nardus,* Patchouli = *Pogostemon cablin*, Palmarosa = *Cymbopogon martinii*, Vetiver = *Vetiveria zizanioides*, Indian ginseng = *Withania somnifera*.