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## A review of medicinal and aromatic plants and their secondary metabolites status under abiotic stress

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### Abstract

In developing countries, aromatic and medicinal plants are still used in traditional and alternative medicines. In India, medicinal plants are used in traditional medicine to cure various ailments. In the past decades, several studies highlighted the therapeutic properties and biological activities of medicinal and aromatic plants (MAPs). These MAPs include *Andrographis paniculata*, *Artemisia annua*, *Allium cepa*, *Allium sativum*, *Cymbopogon flexuosus*, *Ferula asafoetida*, *Foeniculum vulgare*, *Mentha piperita*, *Ocimum sanctum*, *Piper nigrum*, *Solanum nigrum*, *Tagetes minuta* and *Trigonella foenum-graecum*. The MAPs contain bioactive secondary metabolites like alkaloids, flavonoids, steroids, terpenes, sesquiterpenes, diterpenes, phenolics and saponins. These secondary metabolites possess antimalarial, anthelmintic, anti-inflammatory, analgesic, antimicrobial, antiarthritic, antioxidant, antidiabetic, antihypertensive, anticancer, antifungal, antispasmodic, cardio protective, antithyroid and antihistaminic properties. These MAPs are also used in Indian traditional medicine for cure of several diseases like diarrhoea, indigestion, pains, congestion, coughs, sinusitis, fever, flu, sore throats, chills, sickness, rheumatism, sprains and muscular pains. Apart from the pharmaceutical industries, MAPs also have significance in industries related to perfumery, cosmetic, liquor and nutrition. Secondary metabolites play a major role in the adaptation of plants to the changing environment and stress condition. Secondary metabolites in plants are affected by both biotic and abiotic stress. High levels of stress in medicinal and aromatic plants can affect the secondary metabolite production. Abiotic (cold, heat, drought, salinity) stress leads to the production of reactive oxygen species (ROS) in the cellular compartments of plant cell. Here we provide a review of the effect of abiotic stress on secondary metabolites of different medicinal and aromatic plants.

**Keywords:** Medicinal and Aromatic Plants (MAPs), abiotic stress, secondary metabolites,

### Introduction

The natural products which contain a curative capacity use for the treatment of major and minor human disease (Verma and Singh, 2008) [41]. According to World Health Organization (WHO), the majority of the populations in the world chiefly depends on the traditional medicines and herbal drugs for primary health care requirements. In India recently 20,000 medicinal plant spices have been recorded out of these 800 plant spices are phytochemically used for curing disease (Kamboj, 2000) [38]. Development and synthesis of new drugs, medicinal plants play an important role and approximately more than 100 plants based drugs have been introducing in the market and it gives a remarkable contribution to current therapeutics. In Ayurveda, Siddha and Unani medicinal plants are used for the treatment of various ailments and curing for a different disease. In Indian subcontinent medicinal plant is a vast repository and used as a traditional medicine for the treatment of various chronic diseases, a huge amount of polyherbal formulation is used and in recent research suggested that combination therapy give effective response for the treatment of complex disease (Chopra *et al.*, 1956, Pertrovska, 2012) [19, 62]. Regular scientific investigations have highlighted the contribution and importance of the many plant families i.e. Asteraceae, Apocynaceae, Liliaceae, Rutaceae, Caesalpinaceae, Solanaceae, Piperaceae, Ranunculaceae, Apiaceae, Sapotaceae etc. are used as a medicinal plants and their bioactive compounds which is present in the plants should undergo studies and development of new drugs. During 1950-1970 approximately 100 plants based new drugs were introduced in the market and in 1971 to 1995, new drugs such as paclitaxel, toptecan, irinotecan, teniposide, ectoposide, guggulsterone,

plaunotol, z-guggulsterone, gomishin, nabilone, lectinan, artemisinin etc. have been developed in all over the world. In plant-based drugs provide a remarkable contribution in modern therapeutics; for example in *Rauwolfia serpentina* plant serpentine compound is isolated from the root, possess a hypertension and blood pressure lowering capacity and in *Catharanthus roseus* plant Vinblastine is isolated and used for the treatment of Hodgkins, choriocarcinoma and neck cancer (Farnsworth *et al.*, 1967) [26]. Many plant species have been reported to carry many active compounds that have significant role in management of various human chronic disease such as cancer, diabetes, cardiovascular disorders and so on. In addition to this, many active compound of the herbal plant combine with the other substance to give an effective response in context to biological properties (Kennedy and Wightman, 2011; Shariff, 2001) [39, 72]. Medicinal plant and

their product are used as medicinal supplements all around the world because it contains antiseptic, insecticidal and parasiticidal properties and less or no toxicity and cost effective. Presence of polyphenol compound such as flavonoids and phenol which contained free radical scavenging molecule that are rich in antioxidant activities. Antioxidant work as to neutralize the action or activity of the free radical which cause the tissue injury or damage (Tayyab *et al.*, 2016) [79]. Even today, plants are not only indispensable in health care but form the best hope of source for safe future medicines and also the important source of income for poor people, local communities as well as for the herbal dealer and in India, almost 70% of modern medicines are derived from natural products (Shinwari, 2010) [75]. A summary of various MAPs are given in Table 1.

**Table 1:** Medicinal Plants, their uses and secondary metabolites

Plant	Family	Useful part	Uses	Secondary metabolites	References
<i>Acanthospermum hispidum</i>	Asteraceae	Leaves	Used in cardiovascular disease, cancer, inflammation, allergies. Antimicrobial	Acanthospermol galactoside, flavones, caffeic acid, cis-cis-germacranolides, melampolides, $\beta$ -caryophyllene.	Edewor <i>et al.</i> (2011) [23]
<i>Allium sativum</i> Linn.	Liliaceae	Bulbs	Antiarthritic, digestive, expectorant, febrifuge, stimulant.	S-allyl cysteine sulphoxide (ACSO)	Manoharachary <i>et al.</i> (2016) [48]
<i>Allium cepa</i> Linn.	Liliaceae	Bulbs	Antimicrobial, analgesic, antioxidant, anti-inflammatory, antidiabetic, anti-hypertensive	S-trans-prop-1-enyl cysteine sulphoxide (PECSO)	Jones <i>et al.</i> (2004) [37] and Teshika <i>et al.</i> (2018) [80]
<i>Artemisia annua</i> L.	Asteraceae	Leaves	Antimalarial, anti-inflammatory, anti-cancer	Artemisinin, arteanuin, artemether, arteether, artemetin, casticin, chrysopenetin, circsilineol	Weathers <i>et al.</i> (2012) [86].
<i>Atropa belladonna</i> L.	Solanaceae	Leaves, fruits	Antispasmodic, mydriatic	Atropine, hyoscyamine, hyoscine	Okigbo <i>et al.</i> (2008) [58]
<i>Bacopa monnieri</i>	Scrophulariaceae	Shoot	Antioxidant, anti-inflammatory, antiarthritic, antistress and antiulcerogenic	Bacoside	Sharma <i>et al.</i> (2015) [73]
<i>Cleome ruidosperma</i>	Cleomaceae	Leaves	Analgesic and Anti-inflammatory	Terpenes, alkaloids, flavonoids,	Abdullah <i>et al.</i> (2016) [1], Edeoga <i>et al.</i> (2005)
<i>Cymbopogon flexuosus</i>	Poaceae	Leaves	Anti-inflammatory, analgesic, anti-fungal	Citral, geranium, geranyl acetate, neral, $\beta$ -myrcene	Boukhatem <i>et al.</i> (2014) [15]
<i>Ferula asafoetida</i> Regel.	Apiaceae	Root gum	Used in cough, jaundice, gastritis and rheumatism. Anthelmintic, antispasmodic, antimicrobial, antiseptic, laxative, diuretic	Ferulic acid esters, free ferulic acid, coumarin derivatives	Moghaddam <i>et al.</i> (2015) [54]
<i>Foeniculum vulgare</i> Mill.	Apiaceae	Seed	Diaphoretic, diuretic, carminative, expectorant, febrifuge, stomachic, stimulant, appetizer, cardiac stimulant, vermifuge	Furocoumarins imperatorin, psoralen, bergapten, xanthotoxin, isopimpinellin, quercetin, kaempferol	Nassar <i>et al.</i> (2010) [56]
<i>Matricaria chamomilla</i>	Asteraceae	Leaves	Spasmolytic, anti-inflammatory, antibiotic.	Herniarin, umbelliferone	Eliasova <i>et al.</i> (2004) [24]
<i>Mentha piperita</i> Linn.	Lamiaceae	Leaves	Carminative, spasmolytic, anti-tumour, anti-diabetes, anti-nociceptive, etc	Hesperidin, rosmarinic acid, didymin, buddleoside, diosmin	Zhao <i>et al.</i> (2018) [88]
<i>Ocimum sanctum</i>	Lamiaceae	Leaves, stem, seeds, flower, root	Anticancer, antidiabetic, antifungal, hepatoprotective, cardioprotective, analgesic, antispasmodic	Eugenol, rosmarinic acid, carvacrol, oleanolic acid	Prakash <i>et al.</i> (2005) [64]
<i>Papaver somniferum</i> L.	Papaveraceae	Flower, seeds	Analgesic, narcotic	Morphine, thebaine, papaverine, narceine, codeine	Okigbo <i>et al.</i> (2008) [58]
<i>Piper nigrum</i> Linn.	Piperaceae	Dried fruits	Anti-inflammatory, antihypertensive, anti-thyroids, hepato-protective, anticonvulscent, appetizer, antihistaminic, counterirritant, antifatulant	Piperine	Damanhoury <i>et al.</i> (2014) [21]
<i>Rosa laevigata</i>	Rosaceae	Roots, Leaves, fruits	Astringent, anticancer, antibacterial, carminative, stomachic	Daucosterol, Euscaphic acid, betulinic acid, rosamutin, tomentonic acid, rubuside	Mehboob <i>et al.</i> (2017) [49]
<i>Scrophularia</i>	Scrophularia	Roots	Antifungal, antirheumatic,	Aucubin, catalpol, harpagide,	Wang <i>et al.</i> (2010) [65].

<i>ningpoensis</i>	ceae		antipyretic, diuretic, febrifuge, antihypertensive, antiarthritic, antimalarial	harpagoside, cinnamic acid	
<i>Solanum nigrum</i> Linn.	Solanaceae	Fruits, leaves, roots	Used in chronic enlargement of liver, cough, skin disease, rheumatism and gout, eye diseases	Solasodine	Bhat <i>et al.</i> (2008) [14]
<i>Tagetes minuta</i> L.	Asteraceae	Leaves	Anti-leishmanial, antimalarial, antispasmodic	Quercetin-3-methyl ether, quercetin, axillarin-7-O- $\beta$ -D-glucopyranoside, quercetin-3,6-dimethyl ether.	Musayeib <i>et al.</i> (2014) [55]
<i>Trachyspermum ammi</i>	Apiaceae	Seeds	Anti-spasmodic, antioxidant, antinociceptive, antihypertensive, antilithiasis, diuretic, antitussive, nematocidal	Thymol, para-cymene, $\alpha$ - and $\beta$ -pinene and $\gamma$ -terpinene.	Bairwa <i>et al.</i> (2012) [11]
<i>Trigonella foenum-graecum</i> Linn.	Fabaceae	Seeds	Aphrodisiac, curminative, astringent, demulscent, supplicative, aperients, diuretic, emollient, anti-inflammatory	Trigonellin, saponins, diosgenin	Mehrafarin <i>et al.</i> (2010) [50]
<i>Vitex negundo</i> Linn.	Verbenaceae	Leaves	Anti-arthritic, anodyne, appetizer, cephalic, cardiac, astringent, emmenagogue, demulscent, febrifuge, expectorant	Viridiflorol, $\beta$ -caryophyllene, sabinene, 4-terpineol, globulol, protocatechuic acid, oleanolic acid, flavonoids	Vishwanathan <i>et al.</i> (2010) [84]; Singh <i>et al.</i> (1999) [76]; Surveswaran <i>et al.</i> (2007) [77]
<i>Withania somnifera</i>	Solanaceae	Roots	Antioxidant, anti-inflammatory, antineoplastic, antiproliferative, antifibrotic, cardiovascular, amnesia, neurodegenerative	Withanine, withananine, somniferine, somnine, withanolides, withaferin A.	Brant <i>et al.</i> (2016) [16]; Bharti <i>et al.</i> (2016) [12]; Chauhan <i>et al.</i> (2015) [18]
<i>Zingiber officinale</i> Rosc.	Zingiberaceae	Rhizomes	Rheumatoid arthritis, dyspepsia, anorexia, nausea, antispasmodic	Gingerols, zingiberene, geranial, geranyl acetate.	Sasidharan <i>et al.</i> (2012) [70]

### Abiotic stress

Various kinds of abiotic stresses are prospective harmful to the plants like temperature, salinity, drought, flood, radiation, chemical as well as mechanical stresses which affect the concentration of various secondary plant products and reduces

the yield of the crops. (Tuteja, 2007) [82]. One of the most significant abiotic stress is drought which affect the growth and development of the plant by reducing the available water level in the soil. (Xu, *et al.*, 2010) [44].

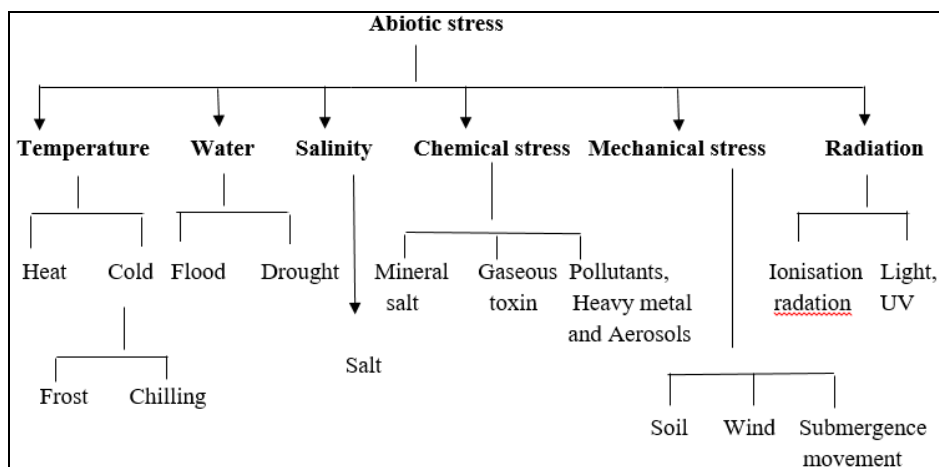


Fig 2: Several abiotic stress signalling affect plants (Akula, *et al.*, 2011) [8].

Abiotic stress give a deleterious effect on plants by drastically alter the metabolic activity of the cell by producing the excess quantity of reactive oxygen species (ROS) in plant. In plant Reactive oxygen species play a dual role such as toxic nature as well as work as key regulators for many biological processes like growth, programmed cell death, cell cycle, hormone signaling and cell responses and development (Miller, G., 2008) [51]. In most of the higher plants primary metabolite is responsible for the synthesis of secondary metabolites and the concentrations of various secondary plant products are strongly dependent on the growing conditions. The significant application of secondary metabolite in nutritive, medicinal, food additive, flavor, pharmaceutical and industrially important pharmaceutical. In most of the cases, presence of abiotic stresses the production of secondary

metabolite is enhances in the aromatic and medicinally important higher plants, which rise up the phytomedicine production and also promote the essential oil production in aromatic plant (Pradhan, *et al.*, 2017) [63]. In this article first of all we give the general information of medicinal important of aromatic and higher plants and the effect of abiotic stress on secondary metabolite of plants.

*Cleome rutidosperma* belongs to the family cleomaceae. It contains many chemical classes like flavonoid, terpenes, alkaloids etc. Cleome supplement with a diverse array of secondary metabolites like essential oil, alkaloids, terpenoids, flavonoids and phenolics which is used as culinary and therapeutic purpose. *Cleome droserifolia* commonly known as 'Samwa' and traditionally used as hypoglycemic agent (Aboushoer *et al.*, 2010) [2]. The *Alliums* are a vast genus

having 700 species, inclusive medicinal value, ornamental flowers and vegetables (Jones *et al.*, 2004) [37]. From the last decade, the medicinal values of *Allium sativum* L. (garlic) and *Allium cepa* L. (onion) oils have been studied and review will include the general properties like antifungal, antimicrobial, insecticidal and antibacterial (Fenwick *et al.*, 1985) [28]. *A. cepa* traditionally used for its remedial characteristics. It was used as blood purifier in ancient Greece. It having pharmacological characteristics including antioxidant, analgesic, hypolipidemic, anti-diabetic, immunoprotective and hypertensive effects (Teshika *et al.*, 2018) [80]. *A. sativum* has been used as a medicinal means from thousand of years. It is a traditional medicinal plant and having beneficial effects like antithrombotic, antiarthritic, hypoglycemic and antitumor activity. A number of organosulphur compounds derived from garlic are garlic oil, aged garlic and fresh garlic extract and it is used to demonstrate the chemopreventive activity of garlic by using these garlic preparations (Thomson *et al.*, 2003) [81].

*Artemisia annua* L. is a native of China, and commonly known as qinghao. Artemisinin, yields from *A. annua* which is a derivative of this compound and potent to antimalarial drug. Artemisinin effective against multidrug-resistant malaria which act on *P. falciparum*, causes cerebral malaria (Mahomoodally *et al.*, 2013) [47]. The artemisinin-based compound has enlarged to their anti-cancer properties in their last decade. However, artemisinin is a bioactive compound and traditionally used in the herbal tea, and shows different biological activities which collaborate the effects of artemisinin against malaria and cancer (Ferreira *et al.*, 2010) [29]. *Bacopa monnieri* L. commonly known as 'Brahmi', an annual creeping herb, mainly used to increase the memory and learning power. Medicinally, used in depression, epilepsy, stress, insomnia, insanity, also used in the treatment of tumors and leprosy (Pareek *et al.*, 2014) [60]. *B. monnieri* also having the property of anti-inflammatory, sedative, antipyretic, analgesic, antistress (Kishore *et al.*, 2005 and Russo *et al.*, 2005) [69].

*Cymbopogon flexuosus* is an aromatic and medicinal plant and used as traditional medicine in developing countries, also used for the treatment of bacterial and fungal infection in Algeria. Essential oil of lemongrass is used as anti-rheumatic, anti-tussive and also treat back ache, sprains in different countries (Boukhatem *et al.*, 2014) [15]. Citral is a main component of lemongrass essential oil (LEO) which is used for anti-inflammatory effect in both human and animals (Han *et al.*, 2017) [17]. Cytotoxic and antimicrobial effect of lemongrass was tested on human dermal fibroblast with the help of disk diffusion method (Adukwu *et al.*, 2016) [3]. *Mentha arvensis* L. is an perennial herb, commonly known as mint, found in China, Siberia, Korea (Lim *et al.*, 2012) [46]. Commonly used as flavouring agents in chewing gums, cosmetics, tobacco, candies, drinks (Khadraoui *et al.*, 2014). It was studied that *Menthae Herba* used as traditional medicine like fever, cold, cough, indigestion, asthma and influenza, also used in facial lotions and toothpaste (Mkaddem *et al.*, 2009). Recently it was investigated that *Menthae Herba* contains various medicinal uses like anti-tumour, anti-inflammatory, anti-diabetes, anti-nociceptive activity etc. (Qian and Wang 2010, Lim *et al.* 2012, Sharma *et al.* 2017, Zhao *et al.* 2017) [49, 46, 17].

*Scrophularia ningpoensis* is a medicinal plant, commonly known as Ningpo figwort and Chinese figwort. Oleic acid, palmitic acid, caffeic acid, flavonoids, harpagoside, phytosterol, rhamnase, cinnamic acid, catalpol, harpagide, saponins, ursolic acid and volatile oil are found as effective

nutrients in *S. Ningpoensis*, in which aucubin, harpagoside, cinnamic acid contains main medicinal value (Tasdemir *et al.* 2008, Jeong *et al.* 2008 and Li *et al.* 2000) [78]. *Tagetes minuta*, belongs to the family Asteraceae. *Tagetes* genus consist of 30 species approximately, it is native to central and southern part of America. It is used as condiments, beverages, medicinal decoction and ornamentals. Its oil is used to flavour the food products like pudding, candy, condiments, etc (Musayeib *et al.*, 2014) [55]. Main components present in the essential oil of this plant is (Z)- $\beta$ -ocimene and dihydrotagetone which is used as antibacterial activity against the test bacteria. Essential oil also contains limonene and epoxyocimene, having the properties of antimicrobial, antioxidant and cytotoxic activity. Among the bioactivities and therapeutic properties it includes germicides, stomachic, antispasmodic, diaphoretic, antiseptic, sedative, repellancy, antihelminthic, bactericidal etc (Gakuubi *et al.*, 2016) [30].

*Trigonella foenum-graecum* L. is an aromatic plant, genus includes 260 species approximately under diffused worldwide, belonging to the family fabaceae (Chaudhary *et al.*, 2018) [17]. It is a medicinal herb and also used as spices, and cultivated throughout the world. It is rich in secondary metabolites that's why it is known traditionally for therapeutic and medicinal value (Baatour *et al.*, 2010) [17]. Sterols, coumarins, essential oils, flavonoids (Ivanov *et al.* 1979, Kwon *et al.* 2002, Ozbek *et al.* 2003, Parejo *et al.* 2004) [35, 59, 61] chemicals are present in the *Foeniculum* species. Certain medicinal activities have been ascribed to some species of *Foeniculum* like antimicrobial and antioxidant activities from the aerial parts (Ruberto *et al.*, 2000) [68], analgesic and anti-inflammatory activities from the fruits of the *F. vulgare* Mill. (Eun and Jae, 2004) [25].

*Vitex negundo* L. is an aromatic shrub, hardy growing to small tree. It is commercially grown as a crop plant in North America, Asia, West Indies. All parts of the plant like leaves, root, seeds, fruits possess phytochemicals or secondary metabolites which helps in making synthetic drugs and artificial medicines. This plant is also used as traditional medicine. (Vishwanathan *et al.*, 2010) [84]. *Zingiber officinale* Roscoe used as medicinal purposes and has been used in nausea and vomiting, and can be nutritionally used for cooking (Hanway *et al.*, 2018) [34]. It is an aromatic herb and mostly distributed in tropical Australia and East Asia and a traditional medicine in India used for arthritis, rheumatism, congestion, coughs, diarrhoea, sinusitis, sore throats, sickness (Badreldin *et al.*, 2008, Sasidharan *et al.*, 2012) [10, 70].

### Status of MAPs under abiotic stress

Salinity stress known to cause oxidative stress and leads to produce reactive oxygen species. *Artemisia annua* L. under salinity stress causes negative effect on growth of the plants (root, shoot length and dry weight). Total chlorophyll content and photosynthetic parameters are reduced under salinity stress. It significantly increases the electrolyte leakage and proline content. Different treatments of sodium chloride (NaCl) 0, 50, 100, 150 and 200 mM to the soil and the activities of antioxidant enzymes like catalase (CAT), peroxidase (POX) and superoxide dismutase (SOD) were significantly increases (Aftab *et al.*, 2010) [4]. Antioxidant enzyme activity and proline activity significantly increases under different concentrations of salt stress and promoted the inhibitory effect on growth and photosynthetic activity. Uptake of different chemical elements like Na<sup>+</sup>, Mg<sup>2+</sup> and K<sup>+</sup> but inhibiting the absorption of Ca<sup>2+</sup> (Li *et al.*, 2014) [44].

Coban *et al.* 2016 studied that the salinity stress shows

inhibition in growth, biochemical properties, development and secondary metabolite deposition in peppermint (*Mentha piperita* L.). Various concentration of NaCl (0, 100 and 150mM) causes decrease in fresh and dry weights of shoot and dry leaf weight decreases with the elevating level of salt. 150mM NaCl shows negative effect on plant that they died on this concentration. Antioxidant enzyme activity, lipid peroxidation and proline content increases significantly and essential oil content decreases as salinity increases. *Matricaria chamomilla* were studied under abiotic stress, in aqueous solution of CuCl<sub>2</sub> secondary metabolites has been evaluated and ene-yne-dicycloether concentration in leaves decreased by 40% (Eliasova *et al*, 2004) [24]. *M. chamomilla* cultivated in different concentrations of copper (3, 60 and 120µM) for 10 days. Dry mass production, chlorophyll, water and nitrogen content significantly decreases at 120µM of Cu in both the leaf rosettes

*Ocimum tenuiflorum* has been studied for its secondary metabolites and genome information. Under abiotic stress like cold, drought, flood and salinity stress, it shows different modifications. *O. tenuiflorum* was more defenceless against cold stress among cold, drought, flood and salinity stresses. It directly affects the secondary metabolites of the plant under severe treatments of all these abiotic stresses. It decreases the eugenol content which is the main secondary metabolite of the plant (Rastogi *et al*, 2019) [66]. In earthen pots, flood treatment was given to plants by regularly maintaining the water level 0.5 inches above the soil (Barnawal *et al*, 2012) [12]. *Scrophularia ningpoensis* Hemsl under drought stress different medicinal components were studied like harpagide, aucubin, catalpol, harpagoside and cinnamic acid. Three levels of osmotic stress for 10 days on *S. ningpoensis* at seedling stage were investigated and the content of components were detected by HPLC analysis. Therefore, the four iridoids glycosides content in roots were higher under osmotic stress than the no osmotic stress, although cinnamic acid decreased (Wang *et al*, 2010) [65].

*Solanum nigrum* L. under salinity stress enhanced the production of solasodine content which is a steroidal alkaloid. Solasodine is alternative to diosgenin, used as progenitor for the commercial production of steroidal drug. Various treatments (0-150mM NaCl) was given on *Solanum nigrum* on various *in vitro* grown tissues like regenerative callus, non-regenerative callus and microshoot derived leaves. In different concentrations of NaCl during *in vitro* production of solasodine, the role of plant growth regulators was studied and concluded that the *in vitro* yield was compared with the field grown plants and the solasodine content was maximum in regenerative callus on the 150mM NaCl grown medium (Bhat *et al*, 2008) [14].

*Trigonella foenum graecum* L. under salinity stress with different concentrations of NaCl (0, 50, 100, 150 and 200mM). Salinity causes disturbance in the mineral nutrition and affect the growth, phenolic content, antioxidant properties and physiological activities of the plants. (Baatour *et al*, 2010) [9]. *Foeniculum vulgare* Mill. shows inhibitory responses in the fresh and dry weights and reduces the chlorophyll a, b and β-carotene content of the seedling, under the effect of salt with different concentrations (25, 50 and 75mM NaCl), Nitrogen deficiency (0N and 0.5N of Hoagland's solution), Iron deficiency (0Fe and 0.5Fe of Hoagland's solution), 2°C cold (2, 3 and 4 hrs) and drought (3, 5 and 7 days). Antioxidant activities significantly increases under all the stresses except 5 to 7 days of drought (Nourimand *et al*, 2012) [57].

*Zingiber officinale* Roscoe such as ginger, under chilling stress it may characteristically exhibits structural injuries and suffer from metabolic decomposition when they are exposed to chilling stress. Enzymatic activities and photochemical activities were inhibited due to chilling stress and produces reactive oxygen species like superoxide, hydroxyl radicals and hydrogen peroxide leads to cause serious oxidative damage (Li *et al*, 2014) [44].

## Conclusion

There has been tremendous increase in the consumption and demand for medicinal plants in last decade. Scientific research on MAPs, is opening new horizons in the potential of medicines and other natural products. Although, only 20% of the plant flora has been studied and around 60% of synthetic medicines are originated from plants. The essential oil, flavours, fragrances of aromatic plants at industrial level contribute to economy of developing countries by export earnings and import substitution. Chemotherapeutic agents play a significant role in general and management of human clinical conditions. Many cancer, diabetic, tumour, thyroid, malarial chemotherapeutic agents extracted from plant sources and have been produced in large quantities by using plant hormones which are grow in abiotic stress condition.

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