PERENNIAL SPICE CROPS: BLACK PEPPER, CINNAMON, CLOVE AND NUTMEG

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Summary

Perennial spice crops like black pepper, cinnamon, clove and nutmeg provide livelihood security to a large number of people in Asia and the Pacific region. Black pepper originated in the Western Ghats, India. Black pepper of commerce was originally a forest product, but was later domesticated as the demand for this spice considerably increased. Many location-specific cultivars now exist, and a few high-yielding ones were developed through selection and crop breeding. The first hybrid pepper, *Panniyur-1*, developed over four decades ago, is still popular in major producing countries like India, Sri Lanka, Brazil, etc. Black pepper is cultivated both as a mono-crop and intercropped with coffee, cardamom, tea, areca nut and coconut.

Perennial spice crops require hot humid weather with an annual rainfall between 1,000 and 2,500 mm, altitude from sea level to a maximum of 1500 meters, and a temperature between 10° and 35° C. However, each crop has its specific agro-ecological requirements. Elite growers apply Good Agricultural Practices (GAP) or organic production systems. The GAP include integrated nutrition and disease and pest management strategies with an emphasis on the use of natural enemies and antagonistic organisms.

Spice products are used in food and flavoring industries and in traditional and local medicine. Sri Lanka has been a major producer of cinnamon and has maintained this position even today. Indonesia is the major producer of cloves and nutmeg. India has identified its own varieties of cinnamon and nutmeg that have better quality attributes.

Vegetative propagation techniques have been developed to propagate the elite lines for distribution to planters. Since plagiotropic shoots are used predominantly to produce nutmeg grafts, the canopy remains compact and ideally suited as an intercrop in coconut gardens. In this chapter an overview of the history, crop description, breeding, agronomy and uses of four perennial spice crops are discussed.

1. Introduction

Perennial spice crops (black pepper, cinnamon, clove and nutmeg) are predominantly cultivated in Asia and the Pacific, and only to a limited extent in Africa and America. They are used as ingredients in food, alcoholic beverages, medicine, perfumery, cosmetics, and coloring in most parts of the world. They are appreciated for their flavor, aroma and color and have been in use as preservatives for thousands of years.

There are over one hundred spices recognized all over the world, and from India alone about fifty species are exported to over seventy countries around the globe. The habit of spice plants ranges from herbaceous to woody climbers and trees, and the commercialized products are obtained from leaves, bark, flower buds, rhizomes, roots, fruits, seeds and aril. Their processing techniques are varied and depend on the end uses.

For centuries spices are also used in traditional systems of medicine, especially in Asia. They are known for their role in therapy and pharmacology. Most of the medicinal properties are attributed to secondary metabolites, many of which are identified and characterized as: flavonoids, terpenoids, sulfides, polyphenolic compounds, carotenoids, saponins, plant sterols, etc. Health benefits of spices include carminative, hypolipidemic, antidiabetic, antilithogenic, anti-inflammatory, antioxidant, antimutagenic and anticarcinogenic properties. Information on phytochemical components, bioactive principles, mechanism of action and therapeutic effects have been scientifically investigated through clinical trials in recent years.

2. Black Pepper

Black pepper (*Piper nigrum* L., family Piperaceae), is a perennial climber grown for its fruits that are used as spice and medicine. The produce is known as pepper with prefix black, green and white to describe the appearance of the product. In order to distinguish this from hot pepper obtained from *Capsicum* spp., the term black pepper is used to refer to the plant and also the produce. Various commercial black pepper products are known. The most common is the black pepper of commerce where the mature fruits are dried and used; white pepper is the product after removing the fruit wall (pericarp); pepper in brine is the immature fruit preserved in brine; canned pepper the mature fruit dehydrated and preserved, etc.

The quality of black pepper is decided by two attributes: aroma and pungency. The former is due to an essential oil and the pungency to an alkaloid, piperine. The volatile oil is a complex cocktail of more than eighty components that include monoterpenoids, ditrerpenoids, triterpenoids, terpene alcohols, aldehydes, etc. The most important constituents of the essential oil are β-caryophyllene, limonene and β-pinene. Pepper vines are weak stemmed climbers and the supports used for growing them are either live trees or dead supports (standards) such as wooden poles, pillars made of granite stone or reinforced cement concrete. Living support trees commonly used are *Erythrina indica*, *Garuga pinnata*, *Glyricidia sepium*, *Ailanthus malabarica* and *Grevilea robusta*. Occasionally, *Ceiba pentandra*, *Albizzia lebec*, *Sesbania* spp. and other forest trees with erect growing stem are also used.

In Brazil, China, Indonesia, Malaysia, Thailand and Vietnam pepper is cultivated as mono-crop, and the height is restricted to 4-6 m giving a columnar appearance (Fig.1). In India and Sri Lanka pepper is cultivated as an intercrop in coconut and areca nut gardens and on shade trees of coffee and tea plantations where the height is unlimited.

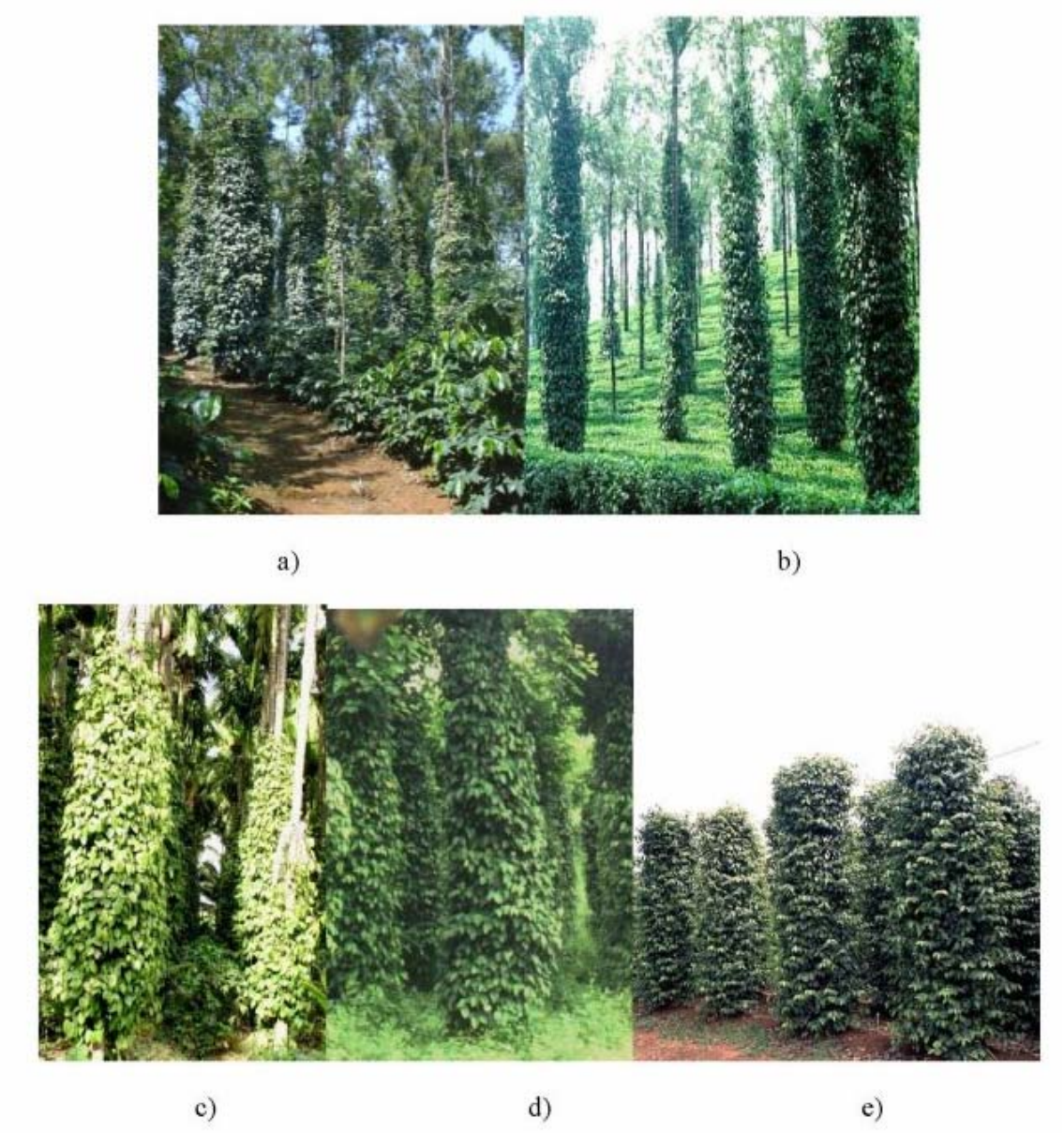

Figure 1.Cultivation of black pepper as intercrop and monocrop. a) in coffee plantations; b) in tea plantations; c) trailed on Areca nut palms; d) as a monocrop on live standards; e) on wooden poles (Courtesy A. Sudhakaran).

2.1. Origin and Distribution

Piper nigrum is a native of the Western Ghats of India. It occurs wild in the hills of Assam and north Burma, but may have become naturalized in this region from an early introduction. It was taken to Java between 100 BC and 600 AD. Marco Polo reported pepper in Malaysia in 1280. In the 16th century, pepper was grown on the west coast of

India with Malabar as the center, and with smaller production areas in Java, Sunda, Malacca, etc.

Pepper was mentioned by Theophrastus (372-287 BC), who recognized two types, namely black pepper (*Piper nigrum*) and long pepper (*P. longum*), both of which were used by the Greeks and the Romans. It was one of the first commercial trade products between the East and Europe.

Black pepper is one of the oldest spices used by man. It has been traded since 1500 BC. Expeditions in search of this spice by European sailors have led to the discovery of new trade routes, circumnavigation of the earth, discovery of hitherto unknown continents, and in due course wars to claim supremacy in spices trade and formation of colonies, and to the creation of several landmarks in human history. When Vasco-da Gama landed at Calicut on 20th May, 1498, it marked the transition of the Indian subcontinent to the modern age, and this event changed the course of not only India, but the rest of the world too.

Presently there are over 26 countries cultivating black pepper, and the production of the top ten (for the year 2007) and the projected production figure for some of these countries for 2010 are listed in Table 1. India was once the largest producer and exporter of this crop but has now been relegated to fourth position mainly due to the new entrants such as Vietnam, and also due to the increase in internal consumption in India itself of black pepper. The productivity of pepper in producing countries is presented in Table 2.

Rank	Area of production	Production (Weight MT)	Projection for 2010 (Weight MT)
1	Viet Nam	89,300	90,000
2	Brazil	77,770	35,000
3	Indonesia	74,131	25,000
4	India	69,000	55,000
5	China	26,210	32,500
6	Sri Lanka	19,390	15,592
7	Malaysia	20,090	23,500
8	Thailand	10,419	NA*
9	Mexico	6,854	NA
10	Madagascar	5,200	NA

*NA= Not available

Table 1. Top ten black pepper producing countries of the world for 2007 and projection for 2010 (Source: http://faostat.fao.org/site/ 342/default.aspx, and *http://www.karvycomtrade. com/downloads/ karvySpecialReports (2010).

Country	Average yield (kg/ha) (2007)
Thailand	3,393
Vietnam	1,742
Malaysia	1,615

China	1,235
Brazil	1,000
Madagascar	625
Sri Lanka	396
Indonesia	346
India	322

Table 2. Average yield or productivity of black pepper in various countries (Source: http://faostat.fao.org/site/342/default.aspx)

2.2. Plant Description

Genus *Piper* has a pan-tropical distribution. Major centers of diversity include Central and South America, South Asia, Malaysia and Indonesia. The genus includes more than one thousand species; about 110 are reported from India. In India, the southwestern and northeastern regions are recognized as two independent centers of distribution for *Piper*. A few of the economically important species of *Piper*, in addition to black pepper are: *P. betle* L. (betel vine), *P. longum* L. (Indian long pepper), *P. retrofactum* Vahl (*P. chaba*, Hunter) (Java long pepper), *P. mullesua* Ham. and *P. cubeba* Lf. (cubebs or tailed pepper) used in indigenous medicine. Black pepper vine has three types of shoots :

- orthotropic climbing shoots that exhibit monopodial growth, develop clinging roots at every node and produce lateral plagiotropic, sympodially growing fruiting branches;
- fruiting branches, plagiotropic, sympodially branching as mentioned above; when rooted and planted, they grow into short bushes and are known as bush pepper; and
- runner shoots which arise at the bottom of mature vines; these are long, monopodially growing, often without branching.

2.3. Botany

Leaves are simple, alternate, coriaceous, dark green and shiny above, pale below, cordate to ovate in orthotropic shoots and ovate to ovate-elliptic on plagiotropic shoots. The lamina is entire with 5-7 veins arising from the leaf base or slightly above; acute or cordate. The leaf size varies with the cultivars and is up to 20cm long and 15 cm broad. Inflorescence is a filiform pendant, called as ‘spike’, borne opposite to the leaves on fruiting branches. The spikes are terminal in development, but are pushed aside by the new shoot developing from the axillary bud and appear opposite to the leaf. The spikes are up to 20cm long, bearing 5-100 minute flowers borne in the axi1s of ovate, fleshy and cupular bracts. Cultivated types are monoecious exhibiting great variability in the composition of male, female and hermaphrodite flowers in the spike.

Self-pollination is the rule in most cultivars, and there is no active pollen transfer mechanism. In bisexual types, the presence of anthers on either side of the gynoecium ensures effective self-pollination, especially in types where both male and female flowers mature at the same time. Protogyny is prevalent in most of the cultivars, with few exceptions. Pollination is passive, and effected through gravitational descending of pollen, often aided by rain water. Geitenogamy is the major mechanism effecting

pollination. The presence of dew or water drops on the spike may further enhance dispersal of pollen grains.

The fruit known is a sessile globose drupe, often called berry, with a pulpy pericarp and has a minute embryo with little endosperm and copious perisperm.

The root system consists of 10-20 main adventitious roots, 2-3 m long from the base of the stem with an extensive mat of secondary and tertiary roots. About 60% of these roots are confined to the top 60cm from the base of the vine.

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Biographical Sketch

Muthuswamy Anandaraj holds a M.Sc. in Botany (1975) from Mysore University and a Ph.D. in Botany (1997) from Calicut University. He has thirty two years of research experience in the field of plantation crops and spices, and headed the Division of Crop Protection, Indian Institute of Spices Research, Calicut, India. His research has mainly focused on the epidemiology and disease management. He has developed and released a *Phytophthora* tolerant variety of black pepper in India and has studied the mechanism of resistance in that variety. He is the author and co-author of several research papers published in national and international journals and has contributed chapters for several books on spices and edited a few of them. He has also contributed chapters for EOLSS.

Dr. Anandaraj is presently working as Project Coordinator of All India Combined Research Projects on Spices (AICRPS) which is responsible for the formulation of research projects, monitoring and release of location specific varieties and technologies for twelve spice crops in India. He is also coordinating the research conducted on three soil-borne pathogens, *Phytophthora, Fusarium* and *Ralstonia* in 17 institutes under Indian Council of Agricultural Research (ICAR).