Cultivation of Tropical, Subtropical, Vegetables, Spices, Medicinal and Aromatic Plants
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Plant spices grown in tropical countries on small scale family farms of commercial farms, to provide foods for human or live stock, in dry or humid regions are highly abundant and taxonomically diversified. Vegetables comprise of a large number of plants, mostly annual, of which different parts like leaf, steam, flowers, fruit, root etc. are eaten. They are rich in nutrients and are essential items of a balanced diet. Vegetables are called protective food as their consumption can prevent several diseases. Many vegetables are important items of commerce and thus can play a major role in the economic development. Generally classification of horticulture plants are based on nature of growth climatic requirement continuation of growth types of fruit parts used botanical relationship, salinity tolerance, ripening behaviour, botanical relationship, hardness or temperature tolerance, cool season vegetables, warm season vegetables, parts used as food, methods of raising, etc. Medicinal and aromatic plants are important for human health. These plants have been used from the prehistoric times to present day. These plants based medicines are consumed in all civilizations. It is believed that the herbal medicine can give good effect to body without causing side effects to human life. Besides, the usage of medical plants has been increasing as an important role that can support the economic system. The medical and aromatic plants for health are used as herbal treatments and therapies that can be new habits for culture. Medicinal and aromatic plants constitute a large segment of the flora, which provide raw materials for use by various industries. They have been used in the country for a long time for their medicinal properties. The decision to cultivate medicinal herbs should only be made in response to demand for particular herbs. The market is very competitive and could easily be oversupplied.

This book majorly deals with classification of horticultural plants, classification of flowers, classification of spices, soil and climatic requirements of horticultural plants, beet root, bottle gourd, harvesting and post harvest management, poly house vegetable production in temperate regions, vegetables growing in containers, tea, performance of plants from cutting, vegetative propagation, rubber, biofertilizers in vegetable cultivation, postharvest management of tropical tuber crops, etc. This is an informative resource of the cultivation, irrigation, manuring, fertilization, harvesting and post harvest management of tropical, subtropical, vegetables, spices, medicinal and aromatic plants. This book is useful for entrepreneurs, ayurvedic institutes, libraries and consultants.

**Content:**
VEGETABLE CROPS

1. CLASSIFICATION OF HORTICULTURAL PLANTS

Plant Kingdom

Classification of Fruits

Based on Nature of Growth
Based on Climatic Requirement
Based on Continuation of Growth
Based on Types of Fruit
Based on Parts Used
Based on Botanical Relationship
Based on Salinity Tolerance
Based on Ripening Behaviour
Based on Ethylene Evolution
Based on Bearing Behaviour

Classification of Vegetables

Based on Botanical Relationship
Based on Hardness or Temperature Tolerance

Cool Season Vegetables
Warm Season Vegetables

Based on Tolerance to Soil Acidity
Based on Tolerance to Salt
Based on Parts Used as Food
Based on Methods of Raising
Based on Forcing
Based on Rate of Respiration

Classification of Flowers

Based on Season of Growing
Based on Colour of Flower
Based on Purpose of Growing
Based on Nature of Growth
Based on Mode of Propagation
Based on Growth Behaviour

Classification of Spices

Based on Completion of Life Cycle
Based on Growth Behaviour
Based on Importance
Based on Part Used
Based on Utility
Based on Cultural Management
Based on Botanical Relationship

Classification of Plantation Crops

Based on Botanical Relationship
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Broccoli (Brassica oleracea var. italica) is of 2 types-heading and purple or green sprouting. Sprouting broccoli is more popular in India. Heading broccoli forms curds like cauliflower, while sprouting broccoli contains a group of green, immature buds and thick fleshy flower stalk forming a head. In India, its cultivation is negligible but now it is becoming increasingly popular in hotels in Mumbai, Calcutta, Delhi and Chennai. It is mostly cultivated in the hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and northern plains of India.

CLIMATE AND SOIL
It is a cool season crop resistant to mild frost. The temperature of 20°-25°C is optimum for its proper growth, while 15°-20°C for heading stage. The heads become loose with rise in temperature.
Broccoli can be grown in a wide variety of soils but deep loamy soil is best-suited. Soil should be well-drained and sufficiently fertilized. Broccoli requires moist soil for fast and proper growth. The shoots become more fibrous under dry soil. The pH of 5.0-6.5 is optimum.

VARIETIES
There is more demand for green sprouting broccoli having green, firm and compact crown heads. The side shoots or heads are less preferred in the Indian market. They are grouped into early, mid and late types. Important varieties are:

Palam Samridhi
This is a high-yielding variety. Its large terminal head weighs about 300-300 g each.
Pusa KTS 1
It is a medium-tall (65-70 cm) variety. Foliage is waxy and dark green with slightly wavy margins. Heads are solid green with small beads slightly raised at the centre. The main head size and weight are about 6.0-15.3 cm and 350-350 g respectively. It matures in 90-105 days after transplanting under temperate climate, while 5-10 days earlier in the tropical plains.

CULTIVATION
The field is prepared like that of Brussels sprout. Generally small-sized plots or beds of 3m x 3m size are prepared for transplanting the seedlings.
Sprouting broccoli is mainly raised from seeds. However, vegetative propagation by cuttings and tissue culture are also practised. Its seedlings are raised in nursery beds just like other cole crops. About 300-500 g seed is sufficient to raise seedlings for a hectare. Mid-September-early-November is sowing time in plains. Generally it is sown during September-October in lower hills. About 3-6 weeks old seedlings are transplanted. The planting of over mature seedlings should be avoided. Seedlings are transplanted 35 cm apart within and between the rows. In very rich soils, spacing can be reduced to 35cm x 30cm to avoid stem hollowness due to rapid plant growth. At a wider spacing, plants produce more laterals. The closer spacing is preferred for mechanical harvesting of the central head. However, closer spacing delays maturity.

Manuring and Fertilization
Use of optimum doses of fertilizers is important for its proper growth since both rapid and slow growth are undesirable. The bud clusters become loose and hollow-stem results from rapid growth, however slow growth affect yield adversely.
Generally, application of 15-20 tonnes of farmyard manure, 60-80kg N/ha and l00kg/ha each of P and K are recommended. The doses differ from place-to-place depending upon the fertility status of the soil. The full dose of P, K and half of N are applied at the time of preparation of land. The remaining dose of N should be topdressed in 2 equal split doses. The first is applied 3-5 weeks after transplanting, whereas second before...
head formation. A high yield of side shoots can be obtained by liberal use of N after harvesting central bud cluster. Micronutrient requirement of broccoli is fairly high. Molybdenum and Boron may be supplied by soil application or foliar sprays.

Irrigation
Broccoli needs sufficient moisture in the soil for uniform and continuous growth of plants. Therefore, frequent irrigation at 10-15 days are given depending upon weather conditions. The dry conditions adversely affect the quality and yield of shoots by being more fibrous. On the other hand waterlogging condition depresses plant growth. Generally furrow system of irrigation is practised.

Interculture
The crop should be kept weed-free. Hoeing is done for breaking the surface crust to facilitate better aeration and water absorption. Since it is a shallow-rooted crop, hoeing should not be done beyond the depth of 5-6 cm close to the plant to avoid injuries to the roots. A light earthing-up at final hoeing is beneficial. Pre-planting sprays of 2 kg/ha of Basalin followed by 1 or 2 hoeings help control weeds effectively.

HARVESTING AND POSTHARVEST MANAGEMENT
The heads having 10-15cm stems should be harvested with a sharp knife when its bud clusters are green and compact. If harvesting is delayed the bud clusters become loose. The central bud cluster or head matures first. The growth of lateral shoots is promoted in the leaf axils. These sprouts may attain a diameter of 3-10 cm and the harvesting is prolonged for several weeks. The closer planting is adopted for economical and single harvest of the central bud clusters. Generally harvesting continues for 3-6 weeks.

Central head weighs about 500-600 g. On an average, its yield varies from 100-150q/ha. However, Pusa KTS 1 provides 100-150 and 60q/ha in hills and plains respectively.

After harvesting, its heads should be immediately sorted, graded, packed in baskets and sent to markets. A high rate of respiration results in deterioration of its quality. They should be cooled at 3.3°C and then packed with ice in crates and stored in refrigerators. They can be stored well for 7-10 days at 3°C. Broccoli can also be preserved in glass jars after lactic acid fermentation.

PHYSIOLOGICAL DISORDERS
Deficiency of molybdenum causes whip-tail in which the lamina of the newly-formed leaves become leathery, irregular and consisting of only mid-rib. This can be prevented by soil application of 1-1.5kg of molybdenum before planting. Foliar application of 0.0-1% solution of ammonium molybdate helps control this disorder.

Browning of heads results due to B deficiency. First water-soaked areas appear on bud clusters which turn pinkish or rusty-brown in advanced stages, resulting in rotting. This can be prevented by soil application of 20kg/ha of borax or sodium borate. Foliar spraying of 0.25-0.5% solution of borax is more effective, especially when the deficiency is acute. The affected portion does not fully recover but helps in appearance of new, healthy bud clusters.

Lettuce
Lettuce (Lactuca sativa) is a very common cool season salad crop. Its leaves are rich in vitamin A (900iu), C (10mg), choline (178mg) and minerals-calcium (50mg) and phosphorus (28mg). If cooked, most of the vitamin C of leaves is lost.

CLIMATE AND SOIL
Since lettuce is a cool season vegetable, it performs well under subtropical and temperate (13Â°-16Â°C) conditions. Both lower and higher temperatures affect its seed germination. High temperature induces bolting also. Increased CO2, enrichment (1,000-1,500ppm) under glasshouse conditions results in high yield.
Well-drained, sandy loam soil, rich in organic matter is best-suited for its cultivation. It is highly sensitive to acidic soils. Neutral soils or slightly acidic (pH 6.0-6.5) soils are suitable.

VARIETIES
Lettuce varieties are classified into various groups-crisp head (heading types with wrinkled non-wrapper leaves, brittle textured), butter head (with small, loose heads having oily soft textured leaves), Cos or Romainer (elongated leaves forming a loaf-shaped head), leaf or bunching (non-heading or leaf type, which produce a rosette of leaves) and stem type (produce thick stem, which are eaten after peeling). A number of varieties exist in each group. 'Great Lakes' (crisphead type), Chinese Yellow (leaf type) and Slow Bolt (leaf type) are varieties recommended for cultivation. Besides, private seed companies also supply seeds of a number of varieties suited to Indian conditions.

CULTIVATION
Propagation
Lettuce is propagated by seed. About 300-500g seed/ha is enough. Seeds have a period of dormancy. Chilling treatments given to seed (by keeping seeds in moist sand or cloth at 3-6°C for 3-5 days) in refrigerator breaks its dormancy and improves germination.

Planting
Early-October-November is sowing time. The seedlings should be transplanted 5-6 weeks after sowing at 35 cm x 35 cm spacing in flat beds.

Manuring
Application of 10-15 tonnes of farmyard manure and NPK@ 25:90:25kg/ha is recommended as basal dose. At the time of head formation or rosette formation, a dose of 25-30kg N/ha should be applied.

Aftercare
Hoeing, irrigation and weeding are important intercultural operations. First hoeing is done 2-3 weeks after planting.

Irrigation
Pre-sowing irrigation is required in nursery/seed-sown field. Similarly it requires a good irrigation after transplanting. A light irrigation is given 3-3 days after transplanting. Subsequently, weekly irrigation is sufficient. Lack of adequate soil moisture results in bolting of plants.

HARVESTING AND POSTHARVEST MANAGEMENT
Heading types are harvested when heads are fully developed. It is better to avoid harvesting when there is rainfall or dew, because the turgid leaves become very crisp and break easily on handling. The produce is graded for removing the diseased and injured leaf/heads and is sent to the market. Its yield varies from 10-12 t/ha.

It can be stored for 3-3 weeks under refrigerated conditions. Pre- and postharvest applications of BA (5-10ppm) helps delay senescence in storage and improves the shelf-life.

PHYSIOLOGICAL DISORDER
Tip burn is a physiological disorder in lettuce. This results in burning or scorching of lateral margins of inner leaves of mature head. Unfavourable seasonal/climatic factors and calcium deficiency are the causes. By applying calcium chloride, this malady can be rectified.

Vegetables Growing in Containers
In big towns and cities due to population pressure, there is hardly any space available in houses or multistorey buildings to grow any vegetable. In such situation, pots and containers can be used to raise a vegetable garden. This practice is known as container gardening.

TYPES OF CONTAINERS
Containers for raising vegetables can be cement pots, earthen pots and pans, wooden barrels, boxes and crates, plastic jars, cans and buckets, tin boxes, cans and drums of various sizes. These containers should have at least one hole of an adequate size at the bottom as in earthen pots, to drain out excess water. These containers can easily be placed on the terrace, window sills, window boxes, balcony and verandah where sunlight is available for the plants.

TOOLS, MANURES, SEEDS, FUNGICIDES AND INSECTICIDES
Certain hand tools are the primary need of a gardener. A container garden needs essentially a khurpi, spade or shovel, watering can, small hand-sprayer, garden hose preferably with a sprinkler, bamboo stakes and string (sutli). Good soil, river sand, well-decomposed organic manure (compost or farmyard manure) and nitrogenous fertilizers (urea or ammonium sulphate), insecticides (Malathion or Endosulphan) and fungicide (Captanf) are important inputs. Quality seed is most important requirement. The seeds can be purchased from the National Seeds Corporation (NSC), agricultural universities, research stations, block development centres and other reliable sources. If one is unable to raise their own seedlings, they may be arranged from reliable nurseries. The container mixture should be prepared by mixing good soil, river-sand and well-rotten organic manure in equal quantities with the help of a khurpi or shovel. The mixture should be free from various soil-borne insects, termites, red ants and cut worms, which generally damage young seedlings. For precaution, add a small quantity of BHC (5%) or Aldrex dust to the mixture before filling it in the containers. After raising a crop for one season the container mixture should be removed and cleaned of roots and exposed to the sun for a few days. This soil could then be reused after mixing one-third the quantity of organic manure and a small quantity of BHC and Captanf.

SUITABLE VEGETABLES AND THEIR VARIETIES
All vegetables cannot be grown successfully in containers. Only specific varieties of selected vegetables perform well in containers. Such vegetables, their suitable varieties, sowing or planting time, period of maturity.

CULTIVATION
Sowing/planting
Most of the vegetables are raised by sowing their seeds directly in containers. The seedlings of brinjal, chilli, tomato, capsicum, lettuce, Brussel's sprout, broccoli, onion, parsley and leek are transplanted in containers. Their seedlings can be raised in earthen pots or pans. A single healthy seedling may be transplanted in each container. Several seedlings, each of onion, lettuce, knol-khol, parsley and leek can be transplanted in a container of the same size. Two seeds of summer squash and 3-5 seeds of clusterbean, cowpea, okra (bhindi) and Frenchbean are sown in such containers. In radish (table types), turnip and beetroot, more number of seeds can be sown in each pot but finally 3-5 seedlings are allowed in a container depending upon the crop. A number of plants can be raised of amaranth, palak, spinach, Fenugreek (methi), mustard, bathua, kulfa and coriander in containers by following thick sowings of their seeds.

Aftercare
Plants in pots and containers need a lot of care and attention. It is essential to water frequently depending on the season, kind of crop and size of the plant and container. Plants need extra water in dry summer season, so watering should be done twice a day (morning and evening). Too much watering can be as harmful in winter as too little in summer. In the rainy season, proper water drainage is essential. If there is heavy rain, containers should be tilted slightly to drain out the excess water from the top. Topdressing with nitrogenous fertilizers improves plant growth and yield of vegetables directly. This can be done by applying urea or ammonium sulphate in small quantities. In general 5-10 g of urea may be applied in moist soil once a week or 10 days, starting from 3 weeks after sowing or 2 weeks after transplanting.
High dose of fertilizer is very harmful since it can kill the plants. If urea or ammonium sulphate is applied in dry soil, the plants must be watered immediately. Plants of cowpea, tomato and bittergourd require staking. Hand-hoeing and weeding with the help of a small khurpi should be done periodically to remove weeds. Weeds should be uprooted gently by hand from amaranth, kulfa, methi, palak, spinach, bathua etc., if thick sowing is done.

Vegetables are attacked by various pests and diseases. Aphids and jassids are small-sucking insects, injuring the plants especially in early stage of their growth. Spraying of Malathion or Endosulphan @ 2ml/litre of water controls these insects. Fruitfly and fruit-borer are serious pests of some vegetable crops. They damage young fruits and make them unfit for consumption. The attacked fruits should be plucked and destroyed. The plants should be sprayed once or twice with Malathion solution @ 1-2ml/litre of water. After spraying, fruits should not be harvested for 7 days for consumption. Fungal diseases (damping off and wilt) and viral diseases affect the plants particularly in the rainy season. Fungal diseases can be controlled by drenching the soil with 'Captaf' solution @ 2g/litre of water. Virus affected plants should be removed and destroyed.

**HARVESTING AND POSTHARVEST MANAGEMENT**

Vegetables harvested at the peak of maturity and used promptly are always superior in nutritional content, flavour and appearance. Leafy vegetables should be picked up frequently when they are most succulent and tender. Root vegetables should be pulled out while still tender as a few days delay makes them pithy, tough and unfit for consumption. Except tomato, all fruit and pod vegetables recommended for container gardening should be picked when they attain proper size and are still tender. Tomatoes are allowed to ripen on plants before harvesting.

Rare vegetables—broccoli, leek, fennel, parsley and parslane (soya)—are not usually available in the market. Most of these are required in a small quantity for consumption. These can be advantageously raised in containers with assured success. Some fruit plants—strawberry, raspberry and gooseberry—can also be grown successfully in medium to big-sized containers.

In fact, vegetable container gardening is an interesting hobby and useful method for growing vegetables in urban areas.