ORGANIC FARM

THE FOOD WEB

INTRODUCTION TO THE PRINCIPLES OF ORGANIC PRODUCTION

Organic systems

A planned approach to organic production is required.

Each individual unit develops its own integrated system based on its own particular circumstances such as crops, livestock, soils, housing etc.

Soil-based

The basis of organic production is a healthy, biologically active soil, with good organic matter reserves, that can supply nutrients for production of grass, crops and vegetables.

This involves providing the soil with materials that can be broken down by soil micro-organisms to release crop nutrients.

It also involves developing cropping rotations that do not over-exploit soil nutrient reserves, thus maintaining soil fertility.

Sustainability and self-sufficiency

Organic production is not simply low-input production, nor is it a return to old-fashioned production.

Organic production is a combination of :

- Top quality husbandry and management
- Modern machinery
- Appropriate modern technology
- Dedication and skill

A productive organic unit will develop a system that is largely self-sufficient in many of the inputs that are often bought in on conventional (non-organic) units.

This makes sense in terms of developing a sustainable system, but in many cases such inputs are often simply not available for purchase, or are very expensive.

Crop nutrients

A balanced crop rotation incorporating legumes is the basis for nutrient provision. This is then supplemented by organic materials including :

- Straw-based manures
- Composted plant materials
- Crop residues
- Green manure crops

It may be possible to utilise manure from another unit, providing it is not from an intensive system, and it is properly composted.

Additional permitted materials that may be used include :

- Rock minerals and liming materials
- A range of processed organic wastes and by-products
- Seaweed and seaweed products

Livestock

In general terms, organic standards prefer that, as much as possible, closed herds/flocks are the goal.

This will involve breeding policies that promote sustainability, aligned with carefully controlled culling and stock replacement.

Livestock feed

Livestock feed is in many cases utilised on the unit on which it is produced. Purchased livestock feed is expensive and can be difficult to obtain.

Feed production should therefore centre around developing a crop rotation that provides the feed requirements, with only materials that cannot be produced on the unit being purchased.

Rotations

All organic systems require a practical, balanced cropping rotation incorporating one or more of the following :

- Grass/clover leys
- Arable crops
- Vegetables
- Green manure crops

The main functions of rotations are :

- Supplying crop nutrients
- Maintaining soil fertility
- Supplying animal fodder and feedstuffs
- Providing weed, pest and disease breaks

Importance of legumes

The key to a successful rotation is the correct incorporation of legumes in the rotation.

This principle is true for livestock, arable and vegetable production units.

The reason is quite simple. Legumes, in association with specific soil bacteria, are able to take atmospheric nitrogen and convert it to nitrogen fertiliser. In short, legumes are the main source of nitrogen on the unit.

Green manures (cover crops)

Although green manuring is not a common technique with conventional producers in the UK, it has been widely adopted by organic producers.

Green manures are crops grown, usually without a saleable value, in order to :

- Provide organic matter and available nutrients
- Provide nitrogen (legumes – eg vetches)
- Protect the soil surface and prevent leaching of nutrients over winter – eg forage rye

- Smother weeds
- Provide weed, pest and disease breaks
- Provide compostable or mulching materials

They are included in rotations to fulfil one or more of the above functions and, depending on the type used, they can be grown for a few weeks, up to a full year.

In some cases a green manure may be grown on land designated as rotational set-aside, and the relevant set-aside payment claimed.

In vegetable units green manures are an essential part of the rotation since they may be the major source of available nutrients, particularly nitrogen, and organic matter. This is especially the case when manures and composts are in short supply.

Weed, pest and disease control

There are no herbicides, and very few pesticides, available to organic producers and alternative means of controlling weeds, pests and diseases are utilised.

The starting point is a good rotation.

Basis of weed control

Weed control is often the main concern amongst new organic producers. Weed control techniques include :

- Correct rotation
- Mechanical cultivations, possibly using specialised equipment
- Grazing
- Topping
- Stale seedbed techniques
- Cover crops and mulches

Basis of pest control

Pest control techniques include :

- Correct rotations and resistant varieties
- Encouraging pest predators
- Physical barriers (eg fleece covers)
- Biological control agents

Basis of disease control

Disease control techniques include :

- Correct rotations and resistant varieties
- Biological diversity
- Good field hygiene
- Permitted fungicides (a limited range of *specified* products is allowed)

Organic crop production

Organic crop production can be an integral part of the cropping rotation. This may be in order to provide animal feed or as a cash crop.

Cropping utilises soil nutrients and, apart from crop residues, does not add to soil fertility.

Cropping should occupy less than 50% of the rotation (preferably considerably less) and should ideally be spread over the rotation cycle.

Organic livestock production

Organic livestock production is extensive, involving modest stocking rates, irrespective of the type of stock involved.

In many cases closed herds or flocks are an important element in reducing the risk of new disease coming into the unit. Limits are put on the number of conventional replacement stock allowed each year.

Livestock must have access to grazing when ground conditions permit.

Animal welfare

A very high degree of animal welfare is built into organic standards due to consumer expectations.

All animals must have suitable bedding and fully slatted houses are not permitted (25% maximum slats is allowed for drainage).

Specific space requirements for winter housing of animals are dictated by the standards.

Livestock feed

Whilst most feed should be from organic or in-conversion sources, limited amounts of non-organic feed are currently allowed; for example up to 10% with beef cattle.

Veterinary

There are very few veterinary medicines that are not allowed in organic production, and animal health is of prime importance.

Full records of all treatments must be maintained.

Most medication is allowed where a real need can be demonstrated. Prior approval must be obtained before some treatments such as vaccinations are given.

However :

- Prophylactic (preventative) administration of medicines to all animals is not allowed
- Animals must be treated on an individual basis

Vegetable production

Organic vegetable production can be an integral part of a farm rotation or can be based on a specialised vegetable unit.

Special attention is required in developing rotations for vegetable production in order to maintain the necessary soil fertility.

Organic seeds and plants

Vegetative propagation materials such as plant transplants, fruit bushes and trees, seed potatoes, onion setts, strawberry runners etc must be from a registered organic source.

Currently, from 1 January 2001, *all* seeds sown on organic units must be certified as organic.

Environmental conservation

Organic standards pay high regard to protection of the environment including :

- Prevention of pollution
- Proper management of trees and hedges

- Provision and maintenance of wildlife habitats
- Retention of species-rich grassland, wetlands etc
- Retention of traditional walls and gates, buildings, monuments and landscape features
- Consultation with conservation bodies

PRODUCTS

The farm will be horticulturally based producing vegetables, herbs, fruit and honey. Initially the emphasis will be vegetables and herbs, then beekeeping, then fruit. The product selection provides a balanced nutrition profile, with attractive rotation and companion farming characteristics. Brief information (description of product (taxonomy, lifecycle), cultivation and nutrition) is given here; more detail is available in the appendix.

Legumes, brassicaeae, graminaeae,.

Legumes

Legumes are critical in organic production for their ability to fix atmospheric nitrogen for use by other plants via the soil. The principal horticultural subfamily is Papilionoideae (bean subfamily).

Certain species of legumes are of regional or worldwide importance because of their commercial use as food for either humans or farm animals. However, despite the high number of legume species in the world, fewer than 20 have been extensively used commercially. **Beans**, **peas**, peanuts, **soybeans**, alfalfa, and **clover** are the major legumes used in world agriculture. Other species of importance include **lentils**, chick-peas, and mung beans.

Beans and peas

Peas are grown for processing on a vast scale. Hand picking is uneconomical. Species to be grown, which are appropriate for the climate are: pisum sativum (peas and mangetout) and vicia faba (broad bean). Phaseolus vulgaris (French) and coccineus (runner) require warmer conditions and may only be grown in hot houses.

Description

Primarily genus pisum and phaseoulus. Good nitrogen fixing qualities. Require support structures and maintenance. May be used as green manure eg vicia fabia after crop harvested.

Cultivation

Pests include pigeons, rabbits, pea moth larvae.

Generally they require good potash level and neutral ph.

Nutrition

These two members of the subfamily Papilionoidea are a staple in the diet of many humans because of their high nutritional value. Beans and peas are high protein, vitamin-rich foods that are easily prepared. Although both beans and peas come in a variety of shapes and colors, the different kinds are usually the result of a single species of bean or pea that has been developed experimentally.

Soybeans (Glycine max).

Description

Cultivation

The United States is the world's largest producer of soybeans. They are cultivated primarily in the midwestern and southern states with Iowa, Illinois, Indiana, and Minnesota producing more than half of the country's crop. Today the other major soybean production regions are in cool temperate zones such as eastern China and southern Brazil. The United States has averaged more than 1.5 billion bushels of soybeans per year since 1970. Corn and wheat are the only crops produced in greater quantity, on average, than soybeans in the United States. In certain years, more soybeans than wheat are harvested.

Soybeans are ordinarily planted in the spring and the seeds harvested in the fall. After the hull is removed, various processes are used to produce soybean oil and soybean meal, which is the crushed beans with the oil extracted. Soybean meal can be used directly as human food but most of it produced in the United States is used for livestock feed. Soybean oil is used to make such products as ice cream, salad dressing, soap, and explosives.

Nutrition

One of the outstanding features of soybeans as a food source for humans or livestock is their high protein content. Protein comprises more than a third of a soybean, which is about twice as high as the protein content of meat.

Lentils

species *Lens esculenta*), small annual legume of the pea family (Leguminosae) and its lens-shaped edible seed, which is rich in protein and one of the most ancient of cultivated foods. Of unknown origin, the **lentil** is widely cultivated throughout Europe, Asia, and North Africa but is little grown in the Western Hemisphere. The seeds are used chiefly in soups and the herbage as fodder. **Lentils** are a good source of protein, vitamin B, iron, and phosphorus.

The plant varies from 15 to 45 cm (6 to 18 inches) in height and has many long, ascending branches. The leaves are alternate, with six pairs of oblong-linear leaflets about 15 mm (0.5 inch) long and ending in a spine. Two to four pale blue flowers are borne in the axils of the leaves in June or early July. The pods are about 15-20 mm long, broadly oblong, and slightly inflated and contain two seeds the shape of a doubly convex lens and about 4-6 mm in diameter. There are many cultivated varieties of the plant, differing in size, hairiness, and colour of the leaves, flowers, and seeds. The seeds may be more or less compressed in shape, and the colour may vary from yellow or gray to dark brown; they are also sometimes mottled or speckled.

The **lentil** has been found in the lake dwellings of St. Peter's Island, Lake Biel, Switz., dating from the Bronze Age. The red pottage of **lentils** for which Esau sold his birthright (Genesis 25:30-34) probably was made from the red Egyptian **lentil**. This **lentil** is cultivated in one or another variety in the Middle East, North Africa, and Europe along the Mediterranean coast and as far north as Germany, The Netherlands, and France. In Egypt, Syria, and other Middle Eastern countries, the parched seeds are sold in shops and are esteemed the best food to carry on long journeys.

Description

Cultivation

Nutrition

Clover

Description

Red clover (Trifolium pratense) and white clover (Trifolium repens) are two of the most common legumes used to add nitrogen to the soil for other crops. When used for this purpose they are simply grown for their nitrogen fixing ability then plowed into the ground as fertilizer. This is commonly called green manuring. Both these clovers are also commonly used as grazing crops and hay. Species in other genera, such as sweet clover in the genus Melilotus, are also referred to as clovers.[1]

Crimson clover (trifolium inccarnatum) is likely to be used because it is a hardy crop that can be planted in late winter and prefers lighter soils. It is also favoured by bees.

Cultivation

Plant in early autumn or in winter. Can be fast growing varieties. Requires little maintentance. Should be dug in a month prior to main crop.

Nutrition

Not grown for nutritive value but as a green manure.

GramineaeCereal Grasses

Cereals are commonly grown for the grains once the grass has gone to seed. In fact cereal grasses may also provide a highly nutritious vegetable crop as well. The grass is cut early and processed, usually pressed or dehydrated, and then the grass may be allowed to grow again to seed when the grains would be harvested.

Wheat

Description

Common cereal grasses are wheat, rye, barley and oat, others are rice, corn and millet.

More than 30 subspecies of wheat (*Triticum*) are known. Some are cultivated, and some still grow wild. A wheat species is classified according to the number and makeup of chromosomes and the structure of the head (spike or ear) of the plant. Chromosomes are the carriers of genetic information in the plant cell. The primitive and early cultivated wheats, such as einkorn (*T. monococcum*), had only 14 chromosomes. They are called diploids. Later types, such as durum (*T. durum*), emmer (*T. dicoccon*), and Polish wheats (*T. polonicum*), have 28 chromosomes and are called tetraploid wheat. The hexaploid wheats--spelt (*T. spelta*), club (*T. compactum*), and most of the common bread wheats (*T. aestivum*)--have 42 chromosomes. Most commercial wheats are either common wheat, used to make bread and flour; durum wheat, a hard wheat used for stock feed and to make pasta such as spaghetti and macaroni; or club wheat, a softer type, low in protein, used for pastry flour. [2]

Cultivation

The grass may be sown in autumn. It will grow through winter and may be harvested in spring.

Cereal grasses should be harvested when the grass is at the jointing stage. This is when the leaves contain the most nutrients in preparation for grain formation. After the leaves are harvested, the plant will repeat the process but may be allowed to finish the grain producing cycle.

Weather that is comfortable for humans is also good for wheat. Wheat needs 12 to 15 inches (31 to 38 centimeters) of water to produce a good crop. It grows best when temperatures are warm, from 70o to 75o F (21o to 24o C), but not too hot. Wheat also needs a lot of sunshine, especially when the grains are filling. Areas with low humidity are better since many wheat diseases thrive in damp weather.

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Spring wheat and winter wheat differ not only in the time they are planted but also in their temperature requirements. Winter wheat, which is planted in the fall, becomes dormant when temperatures drop below freezing. It remains alive but does not grow until the weather becomes warmer. Winter wheat actually requires cold weather in order to develop normally. If planted in the spring, it will not form heads. In extreme cold, however, winter wheat can die. During cold weather, a snow-covered ground insulates the soil and keeps the wheat warmer than the air.

Wheat grows in many types of soil, but it grows best in well-drained loam or clay-loam soils. Two major threats to the wheat plant's growth are poor soil drainage and high levels of soil acidity. The large amount of aluminum usually contained in acidic soils is poisonous to wheat. Some of the elements necessary for growth that are provided by the soil are nitrogen, phosphorus, potassium, sulfur, zinc, copper, boron, manganese, iron, and magnesium. Of these, nitrogen is required in the largest amount because it is part of all the proteins in the plant. Wheat also needs a lot of phosphorus, most of which ends up in the grain. Other nutrients from the soil are needed in smaller amounts, but all must be present for healthy plant growth and color. [3]

Because wheat is a hardy crop, it can sometimes be grown where other crops fail. This is true in the Great Plains of the United States, where there may not be enough rainfall to produce such crops as corn. Even though wheat will grow in such areas, yields may not be high because of the poor weather. Yields of hard wheats can be as high as 70 or 80 bushels per acre, but generally they average 30 or 40 bushels per acre under natural rainfall. In the soft wheat areas of the United States, yields are usually 40 to 50 bushels per acre. In Northern Europe, where the days are long and cool and rainfall is good, yields are often 100 to 150 bushels per acre. [4]

Nutrition

Cereal grasses are nutritionally similar to other dark green vegetables. They are high in chloryphyll, which is a simialr molecule to heme the molecule critical for hemoglobin in blood. 100 grammes of dehydrated wheat grass, for example, contains 32g protein, 51mg vitamin C as well as vitamin K and other nutrients.

Hard wheat used to make bread has 12 to 15 percent protein, while soft wheat has only 7 to 11 percent protein. This extra protein in hard wheat makes bread dough sticky, so that it rises better during baking. The rest of the wheat kernel is 2 percent fat, 2 percent mineral, 65 to 70 percent carbohydrate, 3 percent fiber, and 13 percent water. Wheat grain also contains some vitamin E and several B vitamins, especially niacin. Since the bran contains more protein and vitamins than does the starchy endosperm, whole wheat flour is more nutritious than white flour.[5]

Cruciferae

Cabbage

Description

Cabbage, mustard, and their many relatives belong to the family Cruciferae (cross bearers). The name comes from the shape of the flowers. They have two separate petals and two sepals, which are petal-like parts, arranged in opposite pairs in the form of a Maltese cross.

The species and cultivars to be grown include brassica oleracea (cabbage, broccili - italica, brussel sprouts - gemmifera, cauliflower - botrytis), turnip (brassica rapa), radishes (*Raphanus sativus*), horseradish (*Armoracia rusticana*), watercress (*Nasturtium officinale*).

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Cultivation

Cabbage has winter and summer varieties allowing all year cycle. Generally requires fertile soil with some potash, but varies by species. Pests include cabbage root fly and flea beatle.

Cauliflower can be grown all year round. Fertile soil of at least ph 6.5 is best. Pick young because they do not last long in the field.

Turnip is a fast growing crop.

Kale is a hardy crop for winter growth.

Pests include cabbage root fly, caterpillars and aphids. All generally suffer from club root disease so rotation is critical.

Nutrition

All vegetables in the cabbage group are low in calories and are excellent sources of nutritionally important minerals and vitamins, especially vitamin C. All members of the group have succulent, hairless leaves covered with a waxy coating. This waxy coating often gives the leaf surface a gray-green or blue-green color. Successful cultivation requires a cool growing season and deep, fertile soil. These plants tolerate frost, and some of them tolerate hard freezing at certain periods of their growth. Hot weather, on the other hand, impairs the growth and quality of all members of the group.

Fresh cabbage is eaten raw in salads, or it is cooked. Red cabbage is often pickled. Savoy cabbage is usually cooked before being served. Fermented, shredded cabbage is called sauerkraut.

Turnip

Description

Cultivation

Fast growing, early crop. Best in fertile soil but not too rich. Can be fodder for stock.

Nutrition

Root crops

Many tropical legumes produce an underground root, known as a tuber, that is similar in appearance to a potato. In tropical America tubers called yam beans (genus Pachyrhizus) have been used for food for many centuries. Yet large-scale commercial production has never been successfully carried out. In experimental farming plots, yam beans have given extremely high yields (18 to 22 tons per acre, or 40 to 50 metric tons per hectare). Individual yam-bean tubers are large, up to 6 1/2 pounds (3 kilograms), have a potato-like texture, and a sweet taste. With sufficient research and development, yam beans and other leguminous tubers could become important root crops of tropical areas of the world.

Goosefoot Family (Chenopodiaceae)

Beet root

Including sugar beet. Easy to grow.

Spinach

Description

Spinacia oleracea. Also spinach beet.

The Spinach is an annual plant, long cultivated for the sake of its succulent leaves, a native of Asia, probably of Persian origin, being introduced into Europe about the fifteenth century.

Cultivation

Spinach should be grown on good ground, well worked and well manured, and for the summer crops abundant water will be necessary.

To afford a succession of Summer Spinach, the seeds should be sown about the middle of February and again in March. After this period, small quantities should be sown once a fortnight, as Summer Spinach lasts a very short time. The seeds are generally sown in shallow drills, between the lines of peas. If occupying the whole of a plot, the rows should be 1 foot apart.

The Round-seeded is the best kind for summer use.

The Prickly-seeded and the Flanders kinds are the best for winter and should be thinned out early in the autumn to about 2 inches apart, and later on to 6 inches. The Lettuceleaved is a good succulent winter variety but not quite so hardy.

The first sowing of Winter Spinach should be made early in August and again towards the end of that month, in some sheltered but not shaded situation, in rows 18 inches apart, the plants as they advance being thinned and the ground hoed. By the beginning of winter, the outer leaves will have become fit for use, and if the weather is mild successive gatherings may be obtained up to the beginning of May.

Nutrition

Part Used Leaves.

Spinach is relatively rich in nitrogenous substances, in hydrocarbons, and in iron sesqui-oxide, which last amounts to 3.3 per cent of the total ash. It is thus more nourishing than other green vegetables. It is a valuable part of the diet in anaemia, not only on account of its iron, but also for its chlorophyll. Chlorophyll is known to have a chemical formula remarkably similar to that of haemoglobin, and it is stated that the ingestion of chlorophyll will raise the haemoglobin of the blood without increasing the formed elements. The plant contains from 10 to 20 parts per 1,000 by weight of chlorophyll.

According to Chick and Roscoe (Biochem. Journal, 1926, XX, 137), fresh leaves of Spinach are a rich source of vitamin A, a small daily ration (0.1 gram and upward) encouraging growth and lessening or preventing xerophthalmia in young rats on diets devoid of fat-soluble vitamins. Spinach grown in the open in winter, spring or autumn possesses no antirachitic properties that can be demonstrated by the methods employed. Spinach leaves when irradiated with ultraviolet rays from a Hg vapour quartz lamp become powerfully antirachitic.

Boas (Biochem. Journal, 1926, XX, 153) found that the fresh leaves of winter-grown Spinach added to an experimental diet caused an even greater improvement in the wellbeing of rats and in the rate of growth than was caused by the addition of cod-liver oil. The weight of the skeleton was not, however, proportionally increased. The conclusion was drawn by Boas that winter Spinach contains an amount of vitamin D which is negligible compared with its content of vitamin A.

The leaves contain a large proportion of saltpetre. The water drained from Spinach, after cooking, is capable of making as good match-paper as that made by a solution of nitre.

Spinach

Botanical: Spinacia oleracea (LINN.)
Family: N.O. Chenopodiaceae

- Constituents
- Cultivation

---Part Used---Leaves.
---Habitat---The Spinach is an annual plant, long cultivated for the sake of its succulent leaves, a native of Asia, probably of Persian origin, being introduced into Europe about the fifteenth century.

---Constituents---Spinach is relatively rich in nitrogenous substances, in hydrocarbons, and in iron sesqui-oxide, which last amounts to 3.3 per cent of the total ash. It is thus more nourishing than other green vegetables. It is a valuable part of the diet in anaemia, not only on account of its iron, but also for its chlorophyll. Chlorophyll is known to have a chemical formula remarkably similar to that of haemoglobin, and it is stated that the ingestion of chlorophyll will raise the haemoglobin of the blood without increasing the formed elements. The plant contains from 10 to 20 parts per 1,000 by weight of chlorophyll. During the war, wine fortified with Spinach juice 1 in 50) was given to French soldiers weakened by haemorrhage.

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[Top]

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Solanaceae

Potatoes

Solanum tuberosum

Description

The potato is sometimes called white potato or Irish potato. It is related to the tomato and to the tobacco plant. All belong to the nightshade family Solanaceae. The Potato is nearly related to the Nightshades, belonging to the same genus, Solanum. The potato is botanically unrelated to the sweet potato (see Sweet Potato). The potato's scientific name is Solanum tuberosum.

Its flowers are very similar in form to nightshades, but larger and paler in colour than those of Solanum Dulcamara (Bittersweet Nightshade). The stalks, leaves and green berries possess the narcotic and poisonous properties of the Nightshades. However, the tubers we eat (which are not the root, but mere enlargements of underground stems, shortened and thickened, in which starch is stored up for the future use of the plant), not being acted on by light, do not develop the poisonous properties contained by that part of the plant above ground. The influence of light on the tubers can be observed if in spring-time young green potatoes are exposed to daylight, when it will be found that they become poisonous and have a disagreeable taste.

A herbaceous annual, the potato plant can grow to 20 to 40 inches (50 to 100 centimeters) high. The ends of its underground stems, or stolons, may enlarge greatly to form a few to more than 20 tubers of variable shape and size. The plant's compound leaves manufacture the starch that is stored in the potato's underground tubers. The plant bears white or purplish flowers.

The skin of the potato tuber varies in color from brownish white to deep purple. Its flesh normally ranges in color from white to yellow, but it also may be purple. The tubers bear buds (eyes) that, when the conditions are right, grow into new plants.

The potatoes cultivated in South America as early as 1,800 years ago probably included a mixture of varieties. Today there are more than 500 varieties of potato cultivated. Commercial potato varieties can be classified by their appearance into four groups: rough white, russet (mostly long), round red, and long white. The rough white group includes the Kennebec, Katahdin, Superior, and Norchip varieties. Among the russet potatoes are the Russet Burbank and Norgold Russet varieties. The round red group includes the Red Lasoda and the Red Pontiac. The White Rose is an example of a long white potato variety.

Cultivation

Potatoes grow well in cool climates, in a light sandy or clay loam soil. The plant is not commonly grown from seed but from pieces of the tuber. Each piece must have one or two buds, or eyes, for a plant to sprout and develop. Potato buds may remain dormant after the tuber is fully grown, even under conditions favorable to development, for more than ten weeks. They grow into plants identical to the plant that bore them. Potatoes are always grown commercially by vegetative reproduction which assures a continuation of desired characteristics in the crops. However, because crops grown in this way are usually homogeneous, they are particularly vulnerable to disease.

Potato plants have many enemies. An extremely destructive enemy is the Colorado potato beetle, more commonly called the potato bug. It feeds on the leaves of the plant. Another insect, the potato leafhopper, interferes with the normal physiology of the plant. Its salivary secretions cause leaf-cell hypertrophy that impairs transport of sugars. The resulting sugar accumulation in the leaves destroys chlorophyll and causes the leaves to turn brown and die. This injury, termed hopper burn, can result in the complete loss of a potato crop if not controlled. Potato enemies also include worms; fungus diseases such as early blight, rot, late blight, scab, and wilt; and bacterial and viral diseases. The witches'-broom virus causes the infected plant to produce numerous buds on the above-ground stems of the potato plants. Long, slender stolons resembling aerial roots that are covered with hairs develop from these buds.

Require richness of organic matter and therefore added manure. Many pests/diseases.

Nutrition

Part Used: Edible tubers.

Easily digested, potatoes also have a high nutritional value. A potato tuber is about 78 percent water and about 18 percent starch (carbohydrates). The rest is protein, minerals, and about 0.1 percent fat. Potatoes contain many vitamins, including vitamin C, riboflavin, thiamine, and niacin. Among the many minerals found in potatoes are calcium, potassium, phosphorus, and magnesium. Because they are notably lacking in sodium, potatoes are sometimes suggested for inclusion in low-sodium diets.

Tomato

TOMATO.

Description

The scientific name of the tomato is *Lycopersicon lycopersicum*. The tomato plant is a bushy annual. It has jagged leaves and small yellow bell-like flowers. The plant's tender branches cannot support the modern heavy fruit and must be reinforced with stakes to prevent damage.[6]

Cultivation

Nutrition

Today the tomato is used in soups and salads. Tangy flavor and richness in vitamins A and C make canned tomatoes and tomato juice popular. The plant is the basis of tomato catsup (also spelled ketchup), chili sauce, and other relishes. A century of cultivation has produced a large, smooth, thin-skinned, fleshy fruit instead of the small seedy specimens of the old gardens. In some varieties a single tomato may weigh up to 3 pounds (1.3 kilograms). Some varieties are yellow when ripe, but these do not ship well and are now rarely grown commercially.

Umbelliferae

Within the Apiales are 2 families, Apiaceae (**Umbelliferae**), with about 3,000 species, and Araliaceae, with about 700 species. The plants have compound or cleft leaves and an inferior ovary. The common arrangement of the flowers is into umbels and compound umbels, although other inflorescences are known. Members of the Apiaceae have odours that are uncharacteristic of other families. Among the species cultivated for food or spice are *Anethum graveolens* (dill), *Apium graveolens* (celery), *Carum carvi* (caraway), *Coriandrum sativum* (coriander, or cilantro), *Daucus carota* (carrot), *Petroselinum crispum* (parsley), and *Pastinaca sativa* (parsnip). Other members are poisonous, including *Cicuta* and *Conium* (hemlock). Within the Araliaceae are *Schefflera, Polyscias, Hedera helix* (English ivy), *Oplopanax horridus* (devil's club), and *Panax ginseng* (ginseng). The order dates to between 60 and 70 million years ago.

Carrot

Description

Botanical: Daucus carota, synonyms Philtron (Old Greek). Bird's Nest.

The stems are erect and branched, generally about 2, feet high, tough and furrowed. Both stems and leaves are more or less clothed with stout, coarse hairs. The leaves are very finely divided, the lowest leaves considerably larger than the upper; their arrangement on the stem is alternate, and all the leaves embrace the stem with the sheathing base, which is so characteristic of this group of plants, the Umbelliferae, to which the Carrot belongs. The blossoms are densely clustered together in terminal umbels, or flattened heads, in which the flower-bearing stalks of the head all arise from one point in rays, like the ribs of an umbrella, each ray again dividing in the case of the Carrot, to form a secondary umbel, or umbellule of white flowers, the outer ones of which are irregular and larger than the others.

The wild Carrot is in bloom from June to August, but often continues flowering much longer. The flowers themselves are very small, but from their whiteness and number, they form a conspicuous head, nearly flat while in bloom, or slightly convex, but as the seeds ripen, the umbels contract, the outer rays, which are to begin with 1 to 2 inches long, lengthening and curving inwards, so that the head forms a hollow cup hence one of the old popular names for the plant: Bird's Nest. The fruit is slightly flattened, with numerous bristles arranged in five rows. The ring of finely-divided and leaf-like bracts at the point where the umbel springs is a noticeable feature.

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[6]Excerpted from *The Complete Reference Collection*.

The Carrot is well distinguished from other plants of the same order by having the central flower of the umbel, or sometimes a tiny umbellule, of a bright red or deep purple colour, though there is a variety, D. maritimus, frequent on many parts of the sea coast in the south of England, which differs in having somewhat fleshy leaves and in being destitute of the central purple flower. In this case, all the flowers of the head have often a somewhat pinkish tinge. There was a curious superstition that this small purple flower of the Carrot was of benefit in epilepsy.

Cultivation

A native wild plant common everywhere in the British Islands.

Both the Carrot and Parsnip are striking examples of the effect of cultivation on wild plants. The roots of the wild variety are small and woody, while those of the cultivated kind are fleshy and succulent and grow to a considerable size.

The root of the Carrot consists of Bark and Wood: the bark of the Garden Carrot is the outer red layer, dark and pulpy and sweet to the taste; the wood forms the yellow core, gradually becoming hard, stringy and fibrous. The aim of cultivation, therefore, is to obtain a fleshy root, with the smallest part of wood. This depends on soil and the quality and kind of the seed.

For its successful cultivation, Carrot needs a light, warm soil, which has been well manured in the previous season. The most suitable soil is a light one inclining to sand, a somewhat sandy loam or dry, peaty land being the best, but even heavy ground, properly prepared, may be made to produce good Carrots. Formerly the cultivation of the Carrot was almost entirely confined to the light lands of Norfolk and Suffolk.

The ground should be well prepared some months in advance; heavy ground should be lightened by the addition of wood ash, road scrapings, old potting soil and similar materials. It is essential that the soil be in such a state as to allow the roots to penetrate to their full length without interruption. Previous to sowing the seed, the soil should be lightly forked over, and, if possible, be given a dressing of leaf soil or well decayed vegetable matter, but no fresh manure must be dug into the top spit of ground intended for Carrots and Parsnips, as it may cause the roots to become forked. The crops will, however, benefit by about an ounce of superphosphate to the square yard, raked in before sowing, or by a light dressing of soot.

Sowing of the main crop should be done in calm weather about the middle of March or early in April. The seeds frequently adhere to one another by means of the forked hairs which surround them. These hairs can be removed by rubbing through the hands or a fine chaff sieve. The seeds should then be mixed with about twice the bulk of dry earth, sand or sifted ashes (about one bushel of seeds to 4 or 5 lb. of sand). When the ground is thoroughly prepared and has been firmly trodden, draw flat-bottomed drills from north to south, 1/2 inch deep and 3 inches wide. Distribute the seed along the row evenly and thinly and cover lightly. Carrots can hardly be covered too lightly, 1 inch of fine soil is quite enough, and for ordinary use they may be sown in drills one foot apart, but if extra large roots are desired, more room must be given between the rows. As soon as the young plants are large enough to handle they may be thinned to 6 inches or 8 inches apart. The thinning may be at first to a distance of 3 inches, and then a final thinning later, the second thinnings being used as young Carrots for culinary purposes. Frequent dustings of soot will greatly benefit the crop. Light hoeings between the rows to keep the crop free from weeds is all that is necessary during the period of growth. Partial shade from other crops is often found beneficial.

Scarlet Immediate is the best sort for general purposes.

Main-crop Carrots are generally taken up about the last week in October, or early in November, by three-pronged forks, and stored in sand in a dry place, where they can be kept till the following March or April Some of the roots dug in the autumn can be replanted in February, about 2 feet apart, with the crown or head a few inches below the surface. Leaves and flowers will spring from them, and the seeds produced will ripen in the autumn.

By making successional sowings, good crops of small roots will be always available. In gardens, Carrots are grown in succession of crops from the latter part of February to the beginning of August. For early Carrots sow on a warm border in February: such a sowing, if made as soon as the state of ground allows, will assure early Carrots just when fresh and quickly-grown vegetables are most highly prized. They will be off in time to leave the ground ready for other crops.

After a good dressing of soot has been given, Carrots may be sown again, and even then it leaves the room vacant for winter greens or cabbage for use next spring. Sowing as late as July is generally successful in most districts. Main crops are often sown too early, especially on cold soils. Carrots are liable to attacks of grubs and insects, the upper part of the root being also attacked by the grub of a kind of fly, the best remedy being late sowing, to avoid the period at which these insects are evolved from the egg. Dusting with ashes and a little soot or lime wards off both birds and slugs from the young tender growths.

Carrots are a valuable product for the farmer in feeding his cattle, and for this purpose are raised in large quantities. The produce of an acre of Carrots in Suffolk is on an average 350 bushels per acre, but sometimes much more. In the Channel Islands and Brittany, much larger crops of Carrots and Parsnips are obtained than are yielded in England, the soil being deeply trenched by a spade or specially-constructed plough. Far more Carrots are grown in France, Germany and Belgium for fodder than here. Horses are remarkably fond of Carrots, and when mixed with oats, Carrots form a very good food for them; with a small quantity of oats or other corn, a horse may be supported on from 20 to 30 lb. of Carrots daily. In Suffolk, Carrots were formerly given as a specific for preserving and restoring the wind of horses, but they are not considered good for cattle if fed too long on them. They may also with advantage be given both to pigs and poultry, and rabbits are especially fond of them. The kinds grown for farm purposes are generally larger than those in the kitchen garden and are known as Red Carrots, the more delicate Orange Carrot being the variety used in cooking. Some farmers sow the seeds on the top of the drills, which is said to be an improvement over the gardener, who makes his Carrot-bed on the flat in the ordinary way. This ridge system gives good results the Carrots being clean and well-shaped and free from grubs. The farmers reckon about 2 lb. of seed for an acre for drills, and 5 or 6 lb. if sown broadcast. For ordinary garden purposes, one ounce of seed is reckoned to be sufficient for about 600 feet sown in drills.

Nutrition

Part Used Whole herb.

The juice of the Carrot when expressed contains crystallizable and uncrystallizable sugar, a little starch, extractine gluten, albumen, volatile oil (on which the medicinal properties of the root depend and which is fragrant, aromatic and stimulating), vegetable jelly or pectin, saline matter, malic acid and a peculiar crystallizable, ruby-red neutral principle, without odour or taste, called Carotin.

Carrots contain no less than 89 per cent of water; their most distinguishing dietical substance is sugar, of which they contain about 4.5 per cent.

Owing to the large percentage of carbohydrate material contained by Carrots, rabbits fed for some days on Carrots alone, are found to have an increased amount of glycogen stored in the liver, carbohydrate being converted into glycogen in the body.

Sir Humphry Davy ascertained the nutritive matter of Carrots to amount to 98 parts in 1,000, of which 95 are sugar, and three are starch. Weight for weight, they stand third in nourishing value on the list of roots and tubers, potatoes and parsnips taking first and second places. Carrots containing less water and more nourlshing material than green vegetables, have higher nutritive qualities than turnips, swedes, cabbage, sprouts, cauliflower, onions and leeks. Moreover, the fair proportion of sugar contained in their composition adds to their nourishing value.

In the interesting collection of the Food Collection at Bethnal Green Museum, prepared by Dr. Lankester, we learn that the maximum amount of work produceable by a pound of Carrots is that it will enable a man to raise 64 tons one foot high, so that it would appear to be a very efficient forceproducer. From 1 lb. of Carrots we can obtain 1 OZ. and 11 grains of sugar, while out of the 16 oz. fourteen are water. When we consider that in an average man of 11 stone or 154 lb. weight, about 111 of these are water, we see what a large supply is needful to repair waste and wear and tear.

Cucurbitaceae

GOURDS. Varieties of the pumpkin and squash family grown chiefly for their ornamental fruits are called gourds. The hard-shelled fruits grow in many shapes and sizes. In pioneer days American settlers cleaned and dried the gourd shells and used them for cups, bottles, water jugs, and other utensils. Now gourds are used mainly in winter arrangements with other dried plant material.

The gourd is an annual trailing vine that is sticky, hairy, and musk scented. The leaves are roundish and up to a foot (0.3 meter) across. The vine is fast growing and makes a good cover for the ground or a fence. The flowers may be either white or yellow, depending on the variety. They wither in the sun. In some countries the fruit is eaten as a vegetable.

Gourds belong to the family Cucurbitaceae. Two varieties are commonly grown in the United States. *Cucurbita pepo*, which the Indians cultivated, has yellow flowers and pear-shaped fruits. The white-flowered *Lagenaria siceraria* produces gourds in odd shapes and sizes, known as Hercules'-club, dipper, snake, calabash, and bottle.

Some vines of the *Luffa* genus also are called gourds. The vegetable sponge, or dishcloth gourd, has a fibrous interior that can be dried and used as a sponge. The wax gourd, or Chinese watermelon (*Benincasa hispida*), is native to tropical Asia. [7]

the gourd family of flowering plants, belonging to the order Violales and containing about 90 genera and 700 species of food and ornamental plants. It includes the gourds, melons, squashes, and pumpkins and is occasionally placed in its own order (Cucurbitales).

Most species are prostrate or climb by tendrils. They are annual herbs native to temperate and tropical areas. No member of the family tolerates frost or cold soil. Most species are extremely sensitive to temperatures near freezing, a factor that limits their geographic distribution and area of cultivation. The family includes such economically important food plants as pumpkin, cucumber, gherkin, watermelon, muskmelon, summer squash, winter squash, chayote, cassabanana, squash, and gourd. Cucurbits have a generally low nutrient content; one exception is the winter squash (certain cultivars of *Cucurbita maxima, C. moschata, C. pepo,* etc.).

Members of the family are fast-growing, with long-stalked, palmate leaves that alternate along the stem. Most species have unisexual flowers, which are borne in the leaf axils and have five white or yellow petals. At the side of the leafstalk in annual species there is a simple, sometimes branched, spirally coiled tendril. It is generally regarded by most botanists to be a modified shoot. There are five sepals in each flower; male flowers have five anthers, and female flowers have five carpels. The fruit in most species is a fleshy, many-seeded berry with a tough rind, often attaining considerable size.

Liliaceae

Garlic

[7]Excerpted from *The Complete Reference Collection*.

GARLIC. One of the most popular cooking ingredients and a bulbous vegetable plant that grows beneath the ground, garlic belongs to the lily family, Liliaceae. It is closely related to the onion. Each bulb contains several sections, called cloves, which are covered by a thin papery skin. The cloves--peeled, pounded and dried, minced or crushed--are the part of the plant used for cooking. There are dozens of varieties and wide differences in bulb and clove size and skin color. Garlic is native to Asia, though it also grows wild in Italy and southern France. In the United States it is commercially grown in California, Louisiana, and Texas.

The stalk of the garlic plant usually produces flowers and tiny bulblets, but no seeds. The cloves from the root bulb or from the top bulblets are used to start new plants. A garlic crop is planted in early spring. When the bulbs become full grown in the fall, they are dug up and dried. Garlic is sold as whole bulbs, as a powder, or as juice after it is extracted from the cloves. Garlic tablets, believed by some people to have medicinal properties, are also available. [8]

Description

Botanical: Allium sativum (LINN.)
Family: N.O. Liliaceae

Synonym Poor Man's Treacle.

One of the most popular cooking ingredients and a bulbous vegetable plant that grows beneath the ground, garlic belongs to the lily family, Liliaceae. It is closely related to the onion. Each bulb contains several sections, called cloves, which are covered by a thin papery skin.

The leaves are long, narrow and flat like grass. The bulb (the only part eaten) is of a compound nature, consisting of numerous bulblets, known technically as 'cloves,' grouped together between the membraneous scales and enclosed within a whitish skin, which holds them as in a sac.

The flowers are placed at the end of a stalk rising direct from the bulb and are whitish, grouped together in a globular head, or umbel, with an enclosing kind of leaf or spathae, and among them are small bulbils.

Cultivation

The stalk of the garlic plant usually produces flowers and tiny bulblets, but no seeds. The cloves from the root bulb or from the top bulblets are used to start new plants. A garlic crop is planted in early spring. When the bulbs become full grown in the fall, they are dug up and dried. Garlic is sold as whole bulbs, as a powder, or as juice after it is extracted from the cloves.

The ground should be prepared in a similar manner as for the closely allied onion.

The soil may be sandy, loam or clay, though Garlic flourishes best in a rich, moist, sandy soil. Dig over well, freeing the ground from all lumps and dig some lime into it. Tread firmly. Divide the bulbs into their component 'cloves' - each fair-sized bulb will divide into ten or twelve cloves - and with a dibber put in the cloves separately, about 2 inches deep and about 6 inches apart, leaving about 1 foot between the rows. It is well to give a dressing of soot.

Garlic beds should be in a sunny spot. They must be kept thoroughly free from weeds and the soil gathered up round the roots with a Dutch hoe from time to time.

When planted early in the spring, in February or March, the bulbs should be ready for lifting in August, when the leaves will be beginning to wither. Should the summer have been wet and cold, they may probably not be ready till nearly the middle of September.

Nutrition

Part Used: Bulb.

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[8] Excerpted from *The Complete Reference Collection*.

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The active properties of Garlic depend on a pungent, volatile, essentialoil, which may readily be obtained by distillation with water. It is a sulphide of the radical Allyl, present in all the onion family. This oil is rich in sulphur, but contains no oxygen. The pecular penetrating odour of Garlic is due to this intensely smelling sulphuret of allyl, and is so diffusive that even when the bulb is applied to the soles of the feet, its odour is exhaled by the lungs.

Onion

Root vegetablle

Best grown in multiblocks.

Weed control important. Look out for onion fly and stem eelworm.

ONION. The spherical bulb of the onion was regarded by the ancient Egyptians as a symbol of the universe. It is thought that the onion gets its name from the Latin *unus,* meaning "one." The onion has been used as a cure for a variety of ailments, but it is best known for its use in cooking.

A biennial bulb-bearing plant, the onion has hollow leaves that project from a short stem found at the base of the bulb. It has a fibrous root system. Onions are grown in fertile moist soil from either small black seeds or sets. Sets are small bulbs or a clove of a separable bulb or bulbels, which appear in the flower cluster of some onions. Scallions--also called green onions or table onions--and pearl onions--small white onions--are pulled before maturity. Ripe onions are kept longer in the ground before harvesting. Onions are often dried, dehydrated, boiled, or pickled. The onion's pungent, sulphur-rich oils cause tearing when they mix with moisture in the eyes.

Native to southwestern Asia, onions are produced in large quantities by China, India, the United States, Japan, Turkey, and Spain. Among the many onion varieties are the mild Spanish and Bermuda onions. The common onion (*Allium cepa*) belongs to the lily family Liliaceae. Plants related to the onion are shallots, chives, leeks, and garlic. [9]

Lettuce

Salad crops are high income and do not require crop rotation.

LETTUCE. The world's most popular salad green is lettuce. It originated in western Asia and was popular with the ancient Persians, Greeks, and Romans.

Lettuce grows best in temperate climates with an ample water supply. It grows quickly and must be cut for table use before it produces the long slender stalk upon which its small yellow flowers grow and produce seeds. There are five types of lettuce--crisphead, butterhead, cos, leaf, and stem. Stem, or asparagus, lettuce is grown primarily in China for its tall, thick, edible stems. In Europe the cos and butterhead, or cabbage, types are more common.

In the United States, lettuce is grown commercially in several states. By far the largest producer is California. The most important lettuce commercially is crisphead. The chief varieties are New York (popularly called iceberg), Imperial, and Great Lakes. Butterheads include Big Boston and the small, tender bibb. Most popular of the cos, or romaine, type is Paris white. Leaf lettuce is the easiest type to grow in the home garden. It includes Grand Rapids and the white-seeded and black-seeded Simpsons.

Lettuce belongs to the family Compositae. Its scientific name is *Lactuca sativa.* [10]

Herbs

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[9]Excerpted from *The Complete Reference Collection*.

Lavender

Description

Lavandula angustifolia. Labiatae family.

The bushy, branching shrub has mature stems that become dense and woody. The smooth-edged silver-gray leaves are opposite, lanceolate, somewhat hairy, and up to 2 inches long. The small lavender-purple flowers are in whorls of six to ten flowers, forming terminal spikes 6 to 8 inches long. The fruit is comprised of four shiny gray-brown nutlets. Perennial; hardiness zones 5 to 8. Height up to 36 inches; width 24 inches.

Cultivation

Full sun; light, well-drained soil with a pH of 7.1. Pests and disease None noted. Sow seeds in spring in shallow drills or seed trays. Keep soil moist until the seedlings are well established. Cuttings can be taken from the tips of shoots. Place in sand medium and keep moist. Transplant once the root system is well established.

Companion planting Thyme and lavender help each other grow. Also, lavender helps vegetables to stay healthy and produce more flavor.

Propagation method Seeds, stem cuttings. Bloom time and color June to September; lavender-purple. Harvesting Pick the flower stalks before the last flower on the spike has opened. Harvest on a dry day before the sun is too hot. Hang in bundles upside down in a shady, airy place. Store whole spikes or remove the flowers from the stems. Store in airtight containers. Herbal uses Aromatic, cosmetic, culinary, decorative, and medicinal.

Usage

Language and mythology The name comes from the Latin verb meaning 'to wash.' Lavender was a favorite ingredient in herbal baths of Greeks and Romans. During the Middle Ages, it was considered an herb of love. Because of its clean, fresh scent and insect-repellent properties, it was a popular strewing herb. It also was an ingredient in smelling salts and was used to disinfect wounds during war time.

The dried flowers scent sachets, potpourris, and decorative pillows. The aromatic oil is used in toilet water, cologne, and perfume. Lavender also is used in bath products and stimulating, cleansing facial steams.

It is said to repel mosquitoes.

It can flavor vinegars and jellies. Decorative uses include floral arrangements, wreaths, and wands.

Lavender is said to have some medicinal qualities.

Basil, sweet

Description

Ocimum basilicum. Labiatae family.

The plant has leafy stems and thin, branching roots. The two-lipped white flowers are 1/2 inch long and grow in racemes at the top of stems. The leaves are 2 to 3 inches long, opposite, and ovate with entire margins. They are yellow-green to dark green, depending on soil fertility. The tiny seeds are dark brown.

Cultivation

Annual; hardiness zones are not applicable to annuals. Height 12 to 24 inches; width 12 inches. Full sun; rich, moist, well-drained soil with a pH of 6.

Basil must have warm conditions. For best results, sow in late spring or early summer. It is susceptible to cold and frost, and to drastic temperature change. Pinch the centers as the plants grow to ensure bushiness. Basil can be grown in pots but does not survive indoors. Companion planting Basil attracts butterflies and insects to the garden. It stimulates the growth of companion plants, especially tomatoes and peppers. It is said to repel white flies. Basil and rue do not do well when grown near each other. Propagation method Seeds, cuttings, or transplants. Bloom time and color July to August; white.

Pests and disease Japanese beetles.

Harvesting Harvest in early Autumn before the cold weather arrives and the leaves turn limp and yellow. Cut the long, leafy stalks for drying just before the plant comes into flower. Spread them in a shady place or on wire mesh to encourage quick drying. Do not hang in bunches as the leaves will dry too slowly and can mold. Oven drying is not advised, as the leaves scorch. Basil can be frozen chopped fresh in ice cube trays.

Usage

Language and mythology Basil originated in India, where it was regarded as a sacred herb. The name comes from the Greek basileus meaning 'king'. Once people were no longer fearful of this herb, it was said to be "fit for a king's house." In Haiti basil is thought to belong to the pagan love goddess Erzulie, and in Italy it has been regarded as a sign of love.

Herbal uses Aromatic, cosmetic, culinary, and medicinal. Dried basil is used for its fragrance in potpourris and sachets. It also is used in herbal bath mixtures and to add luster to the hair. Fresh or dried basil is used in cooking to flavor Italian, Mediterranean, and Thai dishes. Fresh leaves are used in tomato and pesto sauces. Basil is good with veal, lamb, fish, poultry, white beans, pasta, rice, tomatoes, cheese, and eggs. It also is used in vinegar and for tea. Basil is said to have some medicinal qualities

Chamomile

Description

Chamaemelum nobile Compositae family

This low-growing plant has flowers that are similar to daisies, but smaller. The solid, solitary central disk is deep yellow, and the rays are silver white to cream. The flowers appear at the end of downy stems, often in pairs. The leaves are alternate and divided into threadlike segments covered with feathery fuzz. The fruit is an achene. Perennial; hardiness zones 3 to 4. Height and width Height 9 inches; width varies, spreads quickly.

Cultivation

Full sun to partial shade; light, dry soil with a pH of 7. Pests and disease None noted. The tiny seeds should be planted in small containers. Transplant seedlings 6 inches apart when big enough to handle. Keep them moist until they are established. For a lawn of English chamomile, plant the herb and keep it well watered until it is established. As the plantlets begin to creep, top-dress lightly with fertilizer to encourage spreading and matting. Companion planting Grow chamomile near onions, cabbages, and wheat. It is said to repel flying insects and increase crop yield. It is grown with peppermint plants to intensify the oil of the peppermint. Propagation method Division, seeds, or cuttings. Bloom time and color June to August; white rays and yellow disk.

Harvesting Flowers should be harvested on a clear morning, before the sun has drawn valuable essences from the blossoms. Pick the opened heads carefully (using scissors) and spread on paper in a cool, dry, airy place. Once the flower heads are papery, store them in a dry screw-top jar.

Usage

The name chamomile is derived from a Greek word meaning 'ground apple.' The plant has an applelike fragrance and flavor. It has long been believed to have gentle healing qualities. The early Egyptians, Greeks, and Romans reportedly used it. In England it was used as a strewing herb for its fresh fragrance, and in Spain it was used to flavor sherry.

Herbal uses Aromatic, cosmetic, culinary, decorative, and medicinal. Dried leaves and flowers are used to scent potpourris. Chamomile also is used for soothing baths and skin lotions. It adds golden highlights to blonde hair. Fresh flower heads can decorate and flavor fresh salads. Dried leaves are used in tea and mixed with half mineral water for a refreshing beverage.

The plant also can be used to make dye (buff, yellow, or gold). Lawns can be created using the low-growing English variety (Chamaemelum nobile), which reaches about 12 inches in height and creeps until it flowers. The taller German variety (Matricaria chamomile) reaches 1 to 2 feet in height and can be used for accent in beds or gardens. The plant is said to have some medicinal qualities.

Marjoram, sweet

Description

Origanum marjorana Labiatae family

Marjoram is similar to oregano, but it has a finer texture. This tender perennial has a dense, shallow root system and is grown as an annual. The square, branched stem has gray hairs. The tiny white, pink, and red flowers are knotlike and shaped before blooming in spherical clusters on spikes or corymbs. The pale green leaves have gray down. They are opposite, elliptical, entire, and 1Ú4 to 1 inch long. The seed is a tiny light brown nutlet. Plant type and hardiness Tender perennial; hardiness zones 9 to 10. Height and width Height 10 to 12 inches; width 10 inches.

Cultivation

Full sun; well-drained, rich soil with a pH of 6.9. Pests and disease None noted. Cultivation Take cuttings of new shoots (about 3 inches long) in late spring when the leaves are firm and will not wilt when placed in sand. Plant well-rooted cuttings in the ground about 12 inches apart or plant in pots outdoors. If seeds are used, sow in a seed-box in spring; then plant outside when the plants are 3 inches tall. Cut out old wood that becomes leggy at the end of winter, and replace plants every four years or so to prevent legginess. Companion planting Marjoram attracts honey bees and helps the garden. When grown near stinging nettle, marjoram’s essential oil is said to become stronger. Propagation method Seeds. Bloom time and color July to September; white, pink, and red.

Harvesting In late summer to early autumn, harvest plants at the peak of bloom or just before they are in full flower. Cut the stems with flower heads attached and dry on screens or hang in a cool, airy place and catch leaves that fall. Strip leaves and flowers after they are crispy and dry. Store in airtight containers. Fresh marjoram also can be frozen in ice cube trays or in foil for up to two weeks.

Usage

In ancient Egypt, marjoram was used in healing, disinfecting, and preserving. Aphrodite, the goddess of love, was said to treasure this herb. The Greeks called this plant Joy of the Mountain and used it to make wreaths and garlands for weddings and funerals. During the Middle Ages, European ladies used marjoram in nosegays.

Herbal uses Aromatic, cosmetic, decorative, and medicinal. Aromatic qualities led to its historical use as a strewing herb. It has mild antiseptic properties and is added to herb bath mixtures. The leaves and flowers are used fresh or dried in cooking many foods, including beef, veal, lamb, poultry, fish, green vegetables, carrots, cauliflower, eggs, mushrooms, and tomatoes. It flavors stews, marinades, sautes, dressing, vinegars, butter, and oils. The plant can be grown in containers. Dried marjoram can be added to herb wreaths, especially culinary wreaths. It also is used to make olive green dye. It is said to have some medicinal qualities.

Thyme

Description

Thymus vulgaris. Labiatae family.

This small, shrublike plant has numerous quadrangular, woody stems that are finely covered with hair. The opposite, sessile leaves are 1/4 to 1/2 inch long, ovate to lanceolate, and slightly rolled at the edges with a pale, hairy underside. The bluish purple to pink flowers are tubular, two-lipped, and less than 1/4 inch long. They are arranged in whorled terminal clusters. The fruit is comprised of four tiny, seedlike nutlets. Plant type and hardiness Perennial; hardiness zones 5 to 9. Height and width Height 12 inches; width 10 to 12 inches.

Cultivation

Full sun to partial shade; light, dry, well-drained soil with a pH of 6.3. Pests and disease Root rot, fungal diseases, and spider mites. Cultivation In spring, sow seeds in a seed tray or scatter directly onto the ground. Keep plants moist while young. Thin to about 6 inches apart. Once well established, thyme does not require much watering or any fertilizer. Propagation by root division should be done in spring. Divide the bush into smaller parts, making sure each piece has rootlets attached. Cuttings should be taken in late spring. Insert 4-inch shoot tips into pots of sand medium and keep them well watered. Companion planting Thyme is said to repel cabbage root flies. Since bees are strongly attracted to thyme, plant where pollination is required (e.g., with tomatoes). Bloom time and color June and July; bluish purple to pink.

Harvest the leafy branches just before the plant flowers. Gather them on a dry day after the dew has dried and before midday. Hang in bundles upside down in a shady, dry, airy place. When the leaves are crisp to the touch, strip them from the stems and store in airtight containers. Harvesting Seeds, layering, cuttings, or division.

Usage

The genus thymus is a Greek word for 'courage.' The name also may be derived from a Greek term meaning “to fumigate” because the herb was burned to repel insects from the house. Fairies were thought to live in a bed of thyme. Historically, it has had a medicinal reputation. A soup of beer and thyme was used to overcome shyness, while a tea of wild thyme was used by Scots to gain strength and courage and to prevent nightmares.

Herbal uses Aromatic, cosmetic, culinary, decorative, and medicinal. The dried flowers and leaves scent potpourris and sachets. Thyme also is used as an antiseptic and stimulant in herb lotions and baths. It flavors vinegars, herbal butter, tea, poultry, fish, stuffings, stews, soups, bread, mayonnaise, mushrooms, and broccoli. Fresh or dried thyme may be added to salads. It is used in wreaths and in floral arrangements. Thyme can be grown in containers. It is said to have some medicinal qualities.

Common Yarrow

Description

Achillea millefolium. Compositae family

This erect herb has fern-like foliage, which is covered with woolly hairs. Leaves are alternate and pinnately divided into many small segments. Leaflets are sharply cleft. Numerous flower heads are composed of disk & ray florets in flat-topped clusters. The fruit is an achene. Plant type and hardiness Perennial; hardiness zone 2. Height and width Height 6-10 inches; width 10-16 inches.

Cultivation

Full sun to light shade; fairly rich, well-drained soil with a pH of 6.0-6.7. Pests and disease Powdery mildew, stem rot, rust. Cultivation Yarrow grows easily from seed, or divide clumps in the spring or fall. If it is used as a ground cover, it may be mowed once per year. Remove dead flowers. Companion planting When planted with other herbs, it will deepen their fragrance and flavor by increasing their essential oils. Yarrow attracts beneficial insects, such as lady bugs who like to lay their eggs on the flowers. It may also help nearby plants to resist disease. Yarrow repels ants, flies, and Japanese beetles. Propagation method Divide(every other year) in spring or fall. Rarely propagated by cuttings. Bloom time and color June - Sept.; white, red, pink, orange, yellow. Harvesting Gather leaves and flowers in late summer. Dried flowers hold their color well.

Usage

Also known as Milfoil, Soldier's Woundwort, and Thousand-seal, this unassuming plant conceals great powers. Considered sacred by some, it is believed to be named after Achilles who used it to staunch blood flow in his army at Troy. The French word millesfeuilles was used to describe this plant's feathery and fern-like appearance. Over time the pronunciation became corrupted and people simply referred to it as Milfoil.

Herbal uses Cosmetic, decorative, medicinal. Cosmetic uses include an astringent and for cleansing and an addition to skin lotions. Decorative use include making a yellow to olive dye and attractive flowers. Flowers dry nicely and can be used in wreaths or arrangements, or use them in fresh florals too. Yarrow is said to have some medicinal properties. Some people are allergic to yarrow.

Nettle

Description

Urtica dioica

The plants, herbaceous perennials, can go to 6 feet tall, with a spread of 12 inches. The roots are tough and persistent, and extremely hard to eradicate. The leaves are dull green, matte, sharply toothed, leaving formic acid and, a burning sensation on the skin. The greenish yellow flowers are minute and insignificant.

Cultivation

All you need to start a colony is a piece of root with an eye.

Usage

It is said that the Roman soldiers tolerated stinging nettles to keep them warm during long marches in their northern territories.

The young leaves are good lightly cooked like spinach, and in soup garnished with croutons and cream.

In self help medicine, the leaves were used to treat rheumatism, as a diuretic, and as a soothing aid to skin problems.

The root fiber was at one time used to make twine, and bunches of fresh leaves were hung in the home to deter flies.

PRODUCTION

Assuming a 20 hectare production base.

Five year rotational cycles of legumes, crucifers and grass. Planting of herbs interspersed with vegetables in companion rows 1:3.

Selecting rotation crops from three classifications: cultivated row, close-growing grains, and sod-forming, or rest, crops. Such a classification provides a ratio basis for balancing crops in the interest of continuing soil protection and production economy. It is sufficiently flexible for adjusting crops to many situations, for making changes when needed, and for including go-between crops as cover and green manures.

Rotation design includes:

- deep root crops alternate with shallow rooting crops,
- high root biomass alternates with low root biomass,
- fertility giving phase alternates with fertility taking phase,
- cleaning crops alternate with weed susceptible crops,

- disease susceptible crop planting spaced out.

Legumes (peas and beans), Crucifers (cabbage, cauliflower, brussel sprouts), potatoes and carrots and turnips, clover and wheat grass, other (spincah, soy etc).

Dairy under consideration. Possibility of outsourcing.

Fruit production to be started later; initially fruit trees in orchard and soft fruits in kitchen garden. Five each of pear, apple, plum, cherry.

Tillage Systems

Deep tilling, in which the soil is plowed deeply, is being superseded in many areas by shallow plowing or no plowing at all. This is one of several techniques that are effective in controlling soil erosion. In the fallow system, which dates back to ancient times, land is plowed and tilled but not planted to a crop. This is to rest and rejuvenate the land. The disadvantage is that such fallow land is more vulnerable to wind and water erosion than is planted land. Plowing along the contours of the land is called contour tillage. This and building terraces on sloping land help to conserve moisture by preventing excessive water runoff on moderately sloping land.

Minimum tillage appears to be gaining acceptance in many areas of the world. With minimum tillage, soil is disturbed as little as possible. In fact, in some areas zero tillage, or no tillage at all, is a growing practice. Weeds can be killed chemically and left as a soil-improving mulch. Crops are planted in untilled land by special machines. Yields of potatoes, parsnips, carrots, gooseberries, broad beans, and brussels sprouts are close to, and sometimes slightly better than, yields under traditional cultivation practices, which consume more time and energy. Corn and soybeans under zero tillage often yield more than under standard cultivation. [11]

Secondary tillage, to improve the seedbed by increased soil pulverization, to conserve moisture through destruction of weeds, and to cut up crop residues, is accomplished by use of various types of harrows, rollers, or pulverizers, and tools for mulching and fallowing. Used for stirring the soil at comparatively shallow depths, secondary-tillage equipment is generally employed after the deeper primary-tillage operations; some primary tillage tools, however, are usable for secondary tillage. There are five principal types of harrows: the disk, the spike-tooth, the spring-tooth, the rotary cross-harrow, and the soil surgeon. Rollers, or pulverizers, with V-shaped wheels make a firm and continuous seedbed while crushing clods. These tools often are combined with each other.

When moisture is scarce and control of wind and water erosion necessary, tillage is sometimes carried out in such a way that crop residues are left on the surface. This system is called trash farming, stubble mulch, or subsurface tillage. Principal equipment for subsurface tillage consists of sweeps and rod weeders. Sweeps are V-shaped knives drawn below the surface with cutting planes horizontal. A mounted set of sweeps provided with power lift and depth regulation is often called a field cultivator.

The typical rod weeder consists of a frame with several plowlike beams, each having a bearing at its point. Rods are extended through the bearings, which revolve slowly under power from a drive wheel. The revolving rod runs a few inches below the surface and pulls up vegetative growth; clearance of the growth from the rod is assisted by its rotation. Rod weeders are sometimes attached to chisel plows.

Some control of weeds is obtained by tillage that leaves the middles between crop rows loose and cloddy. When a good seedbed is prepared only in the row, the seeded crop can become established ahead of the weeds. Plowing with the moldboard plow buries the weed seeds, retards their sprouting, and tends to reduce the operations needed to control them. If weed infestations become bad, they can be reduced somewhat by undercutting.

Since rainfall amount and distribution seldom match crop needs, farmers usually prefer tillage methods that encourage soil-moisture storage at times when crops are not growing. From the soil-moisture standpoint, any tillage practice that does not control weeds and result in greater moisture intake and retention during the storage period is probably unnecessary or undesirable.

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Soil and Nutrients

Essential plant nutrients.

In total, the plant has need of at least 16 elements, of which the most important are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, and magnesium.

The plant obtains carbon and hydrogen dioxide from the atmosphere; other nutrients are taken up from the soil. Although the plant contains sodium, iodine, and cobalt, these are apparently not essential. This is also true of silicon and aluminum.

Overall chemical analyses indicate that the total supply of nutrients in soils is usually high in comparison with the requirements of crop plants. Much of this potential supply, however, is bound tightly in forms that are not released to crops fast enough to give satisfactory growth. Because of this, the farmer is interested in measuring the available nutrient supply as contrasted to the total quantities. This point will be considered later.

The solid content of soils is broadly classified as organic and inorganic. Materials of organic origin range from fresh plant tissue to the more or less stable black or brown degradation product (humus) formed by biological decay. The organic matter is a potential source of nitrogen, phosphorus, and sulfur; it contains more than 95 percent of the total nitrogen, 5 to 60 percent of the total phosphorus, and 10 to 80 percent of the total sulfur. These three elements are cycled through the entire environment of living things (the biosphere). The soil organic matter can be considered as one of the storage points in these cycles. Where nonlegumes are grown in the absence of fertilizer or manures, the crop must gain its nitrogen supply from the organic matter; only a part, however, of the needed phosphorus and sulfur is so supplied.

The inorganic or mineral fraction, which comprises the bulk of most soils, is derived from rocks and their degradation products. The power to supply plant nutrients is much greater in the larger particles, sand and silt, than in the fine particles, or clay. The minerals that comprise the sand and silt in soil contain most of the elements essential for plant growth as a part of their structure. The difficulty is that these minerals decompose so slowly in soil that the rate of supply of the nutrient elements is usually insufficient for good growth of plants.

When the available supply of a given nutrient becomes depleted, its absence becomes a limiting factor in plant growth, and the addition of this nutrient to the soil will increase yields of dry matter. Excessive quantities of some nutrients may cause decrease in yield, however.

Determining nutrient needs.

Determination of a crop's nutrient needs is an essential aspect of fertilizer technology. The appearance of a growing crop may indicate need of fertilizer; in some plants, however, the need for more or different nutrients may not be easily observable. If such a problem exists, its nature must be diagnosed, the degree of deficiency must be determined, and the amount and kind of fertilizer needed for a given yield must be found. There is no substitute for detailed examination of plants and soil conditions in the field, followed by simple fertilizer tests, quick tests of plant tissues, and analysis of soils and plants.

Sometimes plants show symptoms of poor nutrition. Chlorosis (general yellow or pale-green colour), for example, indicates lack of sulfur and nitrogen. Iron deficiency produces white or pale-yellow tissue. Symptoms can be misinterpreted, however. Plant disease can produce appearances resembling mineral deficiency, as can various organisms. Drought or improper cultivation or fertilizer application each may create deficiency symptoms.

After field diagnosis, the conclusions may be confirmed by experiments in a greenhouse or by making strip tests in the field. In strip tests, the fertilizer elements suspected of being deficient are added, singly or in combination, and the resulting plant growth observed. Next, it is necessary to determine the extent of the deficiency.

An experiment in the field can be conducted by adding nutrients to the crop at various rates. The resulting response of yield in relation to amount of nutrient supplied will indicate the supplying power of the unfertilized soil in terms of bushels or tons of produce. If the increase in yield is large, this practice will show that the soil has too little of a given nutrient. Such field experiments may not be practical, because they can cost too much in time and money. Soil-testing laboratories are available in most areas; they conduct chemical soil tests to estimate the availability of nutrients. Commercial soil-testing kits give results that may be very inaccurate, depending on techniques and interpretation. Actually, the most accurate system consists of laboratory analysis of the nutrient content of plant parts, such as the leaf. The results, when correlated with yield response to fertilizer application in field experiments, can give the best estimate of deficiency. Further development of remote sensing techniques, such as infrared photography, are under study and may ultimately become the most valuable technique for such estimates.

Farm manure.

Among sources of organic matter and plant nutrients, farm manure has been of major importance in past years. Manure is understood to mean the refuse from stables and barnyards, including both excreta and straw or other bedding material, while the term fertilizer refers to chemicals. Large amounts of manure are produced by livestock; such manure has value in maintaining and improving soil because of the plant nutrients, humus, and organic substances contained in it.

As manure must be managed carefully in order to derive the most benefit from it, some farmers may be unwilling to expend the necessary time and effort. Manure must be carefully stored to minimize loss of nutrients, particularly nitrogen. It must be applied to the right kind of crop at the proper time. Also, additional fertilizer may be needed, such as phosphoric oxide, in order to gain full value of the nitrogen and potash that are contained in manure.

Manure is fertilizer graded as approximately 0.5-0.25-0.5 (percentages of nitrogen, phosphoric oxide, and potash), with at least two-thirds of the nitrogen in slow-acting forms. Commercial fertilizer equivalent to one ton (900 kilograms) of average manure can be purchased at a fairly low price. Furthermore, the expense of applying 100 pounds (45 kilograms) of 10-5-10 fertilizer is much less than the cost of applying 20 times as much manure. On properly tilled soils, the returns from fertilizer usually will be greater than from an equivalent amount of manure. The application of manure to a crop cannot be controlled as readily as can granulated fertilizer. In general, manure does not provide all the plant nutrients needed and fails to provide any that cannot be supplied by artificial fertilizers. Thus, there is a tendency to discount the value of manure as fertilizer. In underdeveloped countries, however, where artificial fertilizer may be costly or unavailable and where labour is relatively cheap, manure is attractive as a fertilizer.

The main benefits of manure are indirect. It supplies humus, which improves the soil's physical character by increasing its capacity to absorb and store water, by enhancement of aeration, and by favouring the activities of lower organisms. Manure incorporated into the topsoil will help prevent erosion from heavy rain and slow down evaporation of water from the surface. In effect, the value of manure as a mulching material may be greater than is its value as a source of essential plant nutrients.

Liming.

Liming to reduce soil acidity is practiced extensively in humid areas where rainfall leaches calcium and magnesium from the soil, thus creating an acid condition. Calcium and magnesium are major plant nutrients supplied by liming materials. Ground limestone is widely used for this purpose; its active agent, calcium carbonate, reacts with the soil to reduce its acidity. The calcium is then available for plant use. The typical limestones, especially dolomitic, contain magnesium carbonate as well, thus also supplying magnesium to the plant.

Another liming material is basic slag, a by-product of steel manufacture; its active ingredient is calcium silicate. Marl and chalk are soft, impure forms of limestone and are sometimes used as liming materials, as are oyster shells. Calcium sulfate (gypsum) and calcium chloride, however, are unsuitable for liming, for, although their calcium is readily soluble, they leave behind a residue that is harmful.

Lime is applied by mixing it uniformly with the surface layer of the soil. It may be applied at any time of the year on land plowed for spring crops or winter grain or on permanent pasture. After application, plowing, disking, or harrowing will mix it with the soil. Such tillage is usually necessary, because calcium migrates slowly downward in most soils. Lime is usually applied by trucks specially equipped and owned by custom operators.

Nitrates/Nitrites[12]

Nitrates/Nitrites Nitrites come from a variety of sources of nitrate within the agricultural environment, including high-nitrate fertilizers. Nitrates are taken into plant tissues and used in the synthesis of proteins, but only at a relatively-slow rate compared to what is often present. For instance, Ag Extension recommendations often specify the application of an entire season's (highly-soluble) nitrogen/nitrate needs at one time. This virtually ensures not only uptake of more nitrate than can be metabolized by a plant at once, but also leaching of further quantities of highly-soluble nitrates into ground water, a common problem in agricultural areas, as well as under dairies and feedlots due to leaching of stored manures. Regulatory agencies in most localities now require covering of manure piles to prevent leaching, but urines are still ignored, as well as nitrate leaching from agricultural applications.

Nitrates and nitrites are metabolized in the human stomach into nitrosamines, which are carcinogenic and corrosive to the system. Soule and Piper (Farming in Natures Image, 1992) report that "At concentrations of forty-five parts per million, [nitrates from fertilizers] can cause fatal methemoglobinemia disease, or "blue baby syndrome" in infants receiving formula made from contaminated water... ON THE AVERAGE, ABOUT 50 PERCENT OF THE FERTILIZER APPLIED IN THE UNITED STATES IS NOT USED BY CROPS" [my caps]. Nitrates are only extremely-slowly degraded, and so very persistent, once they have reached groundwater, due to the absence of oxygen and bacterial action. Further problems with surface waters are produced concurrent with the groundwater problems, of course, including suffocation of fish caused by depletion of dissolved oxygen by nitrate-jazzed bacterial and algal metabolisms gorged on nitrates washed into creeks, rivers and lakes.

The safest way to apply nitrates/nitrogen/manures/ammonia/etc is by incorporation into a mulch with active bacterial and fungal populations, a little at a time, or by using leguminous green manures, which release their nitrogen slowly over a season (40% if mowed, to 60% if tilled in, during the first year, the total over about 3 years). Greenhouse operators, not known for savvy in avoiding chemical use, have nonetheless acknowledged, for reasons having purely to do with productivity and costs, that nitrogen should be applied gradually, in tiny doses, evenly throughout the growing season for maximum effect.

[12] By Jack Rowe. This article was originally a post to the Permaculture MG email list.

Nutritionists recommend holding back nitrogenous fertilizers for several weeks prior to harvesting leafy greens for human or animal consumption, to give the plants time to metabolize nitrogen taken into their tissues in excess of what can be quickly used. This is especially important for young children.

Fertilizers and Lime

Agricultural experts credit greater and more scientific use of fertilizers and lime with a major share of the increase in farm production since 1940. The liming of acid soils in humid areas is a general practice in advanced agricultural countries. The lime reduces the acidity of the soils, making them more productive when planted with most crops.

Farmers dig soil samples from their fields and send them to soil laboratories operated by the government or by private companies. After testing the samples, the technicians recommend a fertilizer mixture, in terms of pounds per acre, of nitrogen, phosphorus, and potassium--the chief elements used by plants. These fertilizers may also contain small amounts of minor elements, called micronutrients or trace elements. Many machines have been developed for applying fertilizers to various crops.

To return organic matter to the soil, thus keeping it in good physical condition as well as providing fertilizer, farmers plow under available manure and cornstalks, alfalfa, clover, and other so-called green manure plants. Residue from the processing of plants and animals is used as organic fertilizer. Waste from fish canneries and meatpacking plants is also widely used. (See also Fertilizer.)

Fertilizer and Pesticide Improvement

Farm manure is the major source of organic matter and plant nutrients in many parts of the world. Manure includes both animal excrement and animal bedding materials such as straw and wood chips.

The beneficial effects of organic matter and chemicals in the growth of crops have long been known. But only recently have sophisticated systems of chemical release and application been generated rapidly. The goal of most research is to determine precisely how much nutrient to add to a crop and when it is best to add it.

Although there is continued use of standard chemical sources of nitrogen--the most needed and most expensive nutrient--such as anhydrous ammonia, ammonium nitrate, and urea, cheaper and better ways of providing nitrogen are available. Concentrated liquid fertilizers are often used, as is customized mixing of fertilizers based on soil and plant analysis.

Larger and more precise fertilizing machines are being developed. Biodegradable tapes, with seed, fertilizer, and pesticide already incorporated, have found acceptance in gardening and application in some commercial agriculture.

The pesticide industry continues to produce standard control products while actively engaging in the search for more effective and safer ones. Herbicides are of increasing importance, especially under zero tillage systems of farming. Fungicides and other protectants against disease are expensive and may not be as advantageous in the long run as the breeding of disease-resistant strains of crops.

The future of chemical pesticides--including insecticides, fungicides, and herbicides--is being reconsidered on several levels: by the manufacturers, the sellers, and the buyers. The concern for environmental quality demands that greater care be given to development and use of these valuable yet potentially hazardous substances. Integrated control--the use of biological agents along with chemicals when necessary--is perceived as more and more desirable. [13]

Sourcing Inputs

Principal inputs are seeds, water, manure, cultivation equipment and labour.

Manure sourced from

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Nettle juice is a useful liquid feed. Requires pulping.

Lime sourced from

Protective structures include plastic mulch, floating film, cloches and polytunnels.

Irrigation by reservoir and river source.

Fallow/animals

Ploughing

Transport: moving dung and compost, haymaking.

Ploughing

Harrowing

Seed bed preparation

Pest Control[14]

Nnuals are prevented from seeding.

What about the bugs? How can we detect and control them?

Cabbage Caterpillars - There are three types of caterpillars which cause considerable damage to the brassicas. The small white butterfly, the cabbage moth and the cabbage white butterfly.

The small white lays eggs singly on the underside of beans. The cabbage white lays clusters of bright yellow eggs on the underside of the leaves making them difficult to see. The cabbage moth lays clusters of eggs on the underside of leaves and they hatch out into small light green caterpillars. All the caterpillars eat a lot of leaf until they are ready to pupate.

Control - Crush between the fingers any eggs found. Once a week is often enough. Take care not to Mistake the elongated eggs of the ladybird with the bullet shaped eggs of the cabbage white. Use a spray of Bacillus Thurnigiensis which is very effective.

Coddling Moth - Larvae of this moth eat into the flesh of fresh fruit. Eggs are laid later in the season, July/August. Eggs are laid on the fruit near the eye. Once there, the fruit is doomed. No sprays are effective once the grub is inside the fruit. Grease bands around the tree stop the grub reaching the fruit or use the very effective coddling moth trap. Natural pheromones (the attractants given off by the female moths) lure male moths into a sticky trap. If there is no mating there will be no maggots. This pheromone is only attractive to the coddling moth male, therefore harmless to all other beneficial insects and bees.

Vine Weevil - The plump legless white larvae (about 10mm long) feed on the roots, corms and tubers of many plants, particularly in greenhouses and conservatories where pots of cyclamin, begonias, ferns, fuchsias, primulas, gloxinias, orchids and many others can be attacked. The first symptoms are

s often the plant wilting or collapsing suddenly, by which time it is too late to control them. The adults, which are seldom seen, vaguely resemble small cockroaches, with two long crooked antennae. They feed at night, eating holes in the leaves of a wide range of plants. The weevils can lay up to 1000 eggs in potting composts and organic matter over a period of 3-4 months. Once there is an infestation they are extremely difficult to control.

[14] Largely taken from article by David Wilkin.

Control - There are not safe effective chemical controls available to the gardener. Affected plants should be knocked out of their pots and the roots and compost closely examined, so that the grubs can be collected and destroyed. It is best to stop the adults reaching the plants. Pots on greenhouse benches can be protected with a sticky barrier of Trappit Glue around the bench top and supports. It can be applied to strips of PVC tape so that it can be removed easily. Individual pots or containers of susceptible plants can also be treated. To help prevent vine weevils getting into a greenhouse, the entire base could be treated with a band of Trappit Glue, particularly across the door and other possible entry gaps. Check the sticky band regularly to prevent bridging by debris.

Carrot Fly - In carrot growing areas, such as East Anglia, and on allotments, carrot fly can frequently be a serious pest limiting the growth of carrots. The creamy-white larvae, up to 10mm long, feed on and in the roots often making the crop unusable. Eggs are laid in late May and June, with a second generation in August and September.

Control - Sow thinly to avoid thinning out the young plants as the smell from the damage attracts the fly. Lay Enviromesh netting over the crop from late May onwards. Burying the edges in the soil, or covering the edges with stones, bricks etc. Alternatively, make a tunnel type clothe with wire hoops. The Enviromesh could also be used to form a half metre high barrier around the crop by cutting it into four equal strips lengthwise (sealing the edges with a flame, such as a gas lighter or blow lamp). Posts should be driven in around the plot, which should be about two metres wide and the mesh stapled or nailed onto them. Allow an inch of the net to be buried into the soil. The barrier prevents the carrot flies from 'homing in' on the crop as they fly close to the ground causing them to fly up and over the crop. This method is widely recommended by organic growing advisers using polythene, but Enviromesh has the advantage that it can be reused over a period of at least five years and its greater rigidity makes it easier to erect and fix into the posts. Enviromesh is also less vulnerable to wind damage than polythene, particularly in exposed areas. (This cover will also protect against the carrot-willow aphid which spreads a carrot virus.)

If Enviromesh netting is placed over the beds after sowing, soil capping and paddling from heavy rain can be reduced, which can lead to improved germination and crops.

When celery and parsnips are covered with Enviromesh, they will also be protected against celery fly (also known as celery leaf miner). These are small flies, the pupae (maggots) of which tunnel into the leaves.

Nonchemical control of insects.

Mechanical and cultural controls.

Light traps that give off radiation that attracts insects have been under test for many years. They have been somewhat successful in controlling the codling moth (*Carpocapsa pomonella*) and the tobacco hornworm (*Protoparce sexta*).

Use of reflective aluminum strips, placed like a mulch in vegetable fields, has reduced or prevented aphid attack and thus protected cucumbers, squash, and watermelons from mosaic diseases. This technique may supplant insecticides, which frequently do not kill aphids quickly enough to prevent crop losses from virus transmitted by them.

For stored products, heat or cold can control many insects that frequent such places. Also, changing the proportions of oxygen, nitrogen, and carbon dioxide in the storage atmosphere can provide control.

Recently, it was discovered that, if adult Indian-meal moths (*Plodia interpunctella*) were exposed to certain wavelengths of sound during the egg-laying period, their reproduction was reduced by 75 percent. The sound waves had a similar effect on flour beetles (*Tribolium* species). Further development is needed, but this method offers potential as a nonchemical control. Other types of physical energy can also kill insects. Light waves, high-frequency electric fields, high-intensity radio frequencies, and gamma radiation have been investigated; some offer promise.

Certain cultural practices can prevent or reduce insect crop damage. These include destruction of crop residues, deep plowing, crop rotation, use of fertilizers, strip-cropping, irrigation, and scheduled planting operations. Such practices are useful but cannot be relied upon entirely to eliminate severe infestations.

Biological controls.

The question of using biological controls has always been of considerable public interest. The control agents include parasites, predators, diseases, protozoa, and nematodes that attack the insect pests. Biological controls cannot replace insecticides entirely, because nature provides for survival of both beneficial and destructive insects. Before the population of a parasite or predator can expand, a high population of the host species must also be present. Sometimes the control agents are far outnumbered by the pest insect. Parasites and predators have furnished good control of the Japanese beetle (*Popillia japonica*), European corn borer (*Pyrausta nubilalis*), alfalfa aphid (*Therioaphis maculata*), alfalfa weevil (*Hypera postica*), and several others.

Microbial agents can be used for control. There exist about 1,100 viruses, bacteria, fungi, protozoa, rickettsiae, and nematodes that parasitize insects. Many pathogens are specific to a particular insect but are harmless to man and domestic animals. It is a possibility that insect pathogens can be produced, packaged, distributed, and applied in much the same way as insecticides.

The ideal solution to insect-control problems is to plant crop varieties that are resistant to attack. The only difficulty is that such varieties are not universally available, and development entails a very long process.

Sterilization of male insects by gamma radiation and their release into a population of wild insects is a promising approach. It has proved successful in control of screwworms and fruit flies, replacing chemicals in some areas. Chemical attractants, which lure insects into contact with small amounts of insecticide or a sterilant, also offer much promise. (see also *Index*: blow fly)

All aspects of insect control considered, it is possible that "integrated control," coordinated employment of more than one method, may be the answer. Combining resistant varieties with a systemic insecticide that leaves the parasites and predators unharmed, for example, has been successful in combatting the spotted alfalfa aphid in California. Preliminary reduction of heavy infestation by chemical spray combined with bait, followed by the sterile-insect technique, provides another example of integrated control. Use of sex attractant in light traps, plus special management of postharvest residues, has controlled the tobacco hornworm. Other examples might be cited, but the principal value of such control methods lies in using less insecticide and thus contributing to maintenance of a good environment.

Nematodes and plant disease can at times be controlled fairly well by crop rotation, deep plowing, and burning of stubble and debris that remain after harvest. Though burning destroys aboveground organisms and permits economical control by chemicals, it contributes to air pollution and destroys organic matter. In another technique, propane-gas flame is applied to living plants as well as stubble to kill disease spores. A virus disease of sugarcane is controlled by heating diseased cuttings in hot-air ovens. Stem rot disease of peanuts (groundnuts) can be controlled by plowing under dead plant debris or by planting the seed on a raised bed followed by application of a preemergence weed killer.

Composting and Mulching

Mulching, covering ground with straw, to control weeds, retain moisture, improve soil structure, add nutrients and keep crops clean and disease free. Can use cereal grass for this purpose.

Compost may be applied. 10% non-organic, ie kitchen scraps, remainder organic.

Landscaping

Waterways will allow habitat for frogs and toads which eat slugs. Hedges and trees will allow nesting for birds which consume fly larvae and eggs.

A selection of trees to be planted including: douglas fir and silver fir, lawsons cypress, yew, black poplar, walnut, silver birch, beech, sweet chestnut, red oak, wych elm, sycamore, norway maple, horse chestnut, small-leaved lime, ash.

By the water bay willow, goat willow, purple willow, grey poplar.

Bushes to include juniper, alder, hazel, holly, mistletoe, rhodedendron.

Irrigation

The first consideration in planning an irrigation project is developing a water supply. Water supplies may be classified as surface or subsurface. Though both surface and subsurface water come from precipitation such as rain or snow, it is far more difficult to determine the origin of subsurface water.

In planning a surface water supply, extensive studies must be made of the flow in the stream or river that will be used. If the streamflow has been measured regularly over a long period, including times of drought and flood, the studies are greatly simplified. From streamflow data, determinations can be made of the minimum, maximum, average daily, and average monthly flows; the size of dams, spillways, and downstream channel; and the seasonal and carry-over storage needed. If adequate streamflow data are not available, the streamflow may be estimated from rain and snow data, or from flow data from nearby streams that have similar climatic and physiographic conditions.

The quality, as well as the quantity, of surface water is a factor. The two most important considerations are the amount of silt carried and the kind and amount of salts dissolved in the water. If the silt content is high, sediment will be deposited in the reservoir, increasing maintenance costs and decreasing useful life periods. If the salt concentration is high, it may damage crops or accumulate in the soil and eventually render it unproductive.

Subsurface sources of water must be as carefully investigated as surface sources. In general, less is known about subsurface supplies of water than about surface supplies, so, therefore, subsurface supplies are harder to investigate. Engineers planning a project need to know the extent of the basic geological source of water (the aquifer), as well as the amount the water level is lowered by pumping and the rate of recharge of the aquifer. Often the only way for the engineer to obtain these data reliably is to drill test wells and make on-site measurements. Usually, a project is planned so as not to use more subsurface water than is recharged. Otherwise, the water is said to be "mined," meaning that as a natural resource it is being used up. (see also *Index*: groundwater recharge)

Two sources of water not often thought of by the layman are dew and sewage. In certain parts of the world, Israel and part of Australia, for example, where atmospheric conditions are right, sufficient dew may be trapped at night to provide water for irrigation. Elsewhere the supply of waste water from some industries and municipalities is sufficient to irrigate relatively small acreages. Recently, due to greater emphasis on purer water in streams, there has been increased interest in this latter practice. (see also *Index*: sewage system)

In some countries (Egypt for example) sewage is a valuable source of water. In others, such as the United States, irrigation is looked upon as a means of disposing of sewer water as a final step in the waste-treatment process. Unless the water contains unusual chemical salts, such as sodium, it is generally of satisfactory quality for agricultural irrigation. Where the practice is used primarily as a means of disposal, large areas are involved and the choice of crop is critical. Usually only grass or trees can withstand the year-round applications.

Before a water supply can be assured, the right to it must be determined. Countries and states have widely varying laws and customs that determine ownership of water. If the development of a water supply is for a single purpose, then the determination of ownership may be relatively simple; but if the development is multipurpose, as most modern developments are, ownership may be difficult to determine, and agreements must be worked out among countries, states, municipalities, and private owners. (see also *Index*: riparian right)

The area that can be irrigated by a water supply depends on the weather, the type of crop grown, and the soil. Numerous methods have been developed to evaluate these factors and predict average annual volume of rainfall needed. Some representative annual amounts of rainfall needed for cropland in the western United States are 12 to 30 inches (305 to 760 millimetres) for grain and 24 to 60 inches (610 to 1,525 millimetres) for forage. In the Near East, cotton needs about 36 inches (915 millimetres), whereas rice may require two to three times that amount. In humid regions of the United States, where irrigation supplements rainfall, grain crops may require six to nine inches (150 to 230 millimetres) of water. In addition to satisfying the needs of the crop, allowances must be made for water lost directly to evaporation and during transport to the fields.

Transport systems.

The type of transport system used for an irrigation project is often determined by the source of the water supply. If a surface water supply is used, a large canal or pipeline system is usually required to carry the water to the farms because the reservoir is likely to be distant from the point of use. If subsurface water drawn from wells is used, a much smaller transport system is needed, though canals or pipelines may be used. The transport system will depend as far as possible on gravity flow, supplemented if necessary by pumping. From the mains, water flows into branches, or laterals, and finally to distributors that serve groups of farms. Many auxiliary structures are required, including weirs (flow-diversion dams), sluices, and other types of dams. Canals are normally lined with concrete to prevent seepage losses, control weed growth, eliminate erosion hazards, and reduce maintenance. The most common type of concrete canal construction is by slip forming. In this type of construction, the canal is excavated to the exact cross section desired and the concrete placed on the earth sides and bottom.

Pipelines may be constructed of many types of material. The larger lines are usually concrete whereas laterals may be concrete, cement-asbestos, rigid plastic, aluminum, or steel. Although pipelines are more costly than open conduits, they do not require land after construction, suffer little evaporation loss, and are not troubled by algae growth.

Water application.

After water reaches the farm it may be applied by surface, subsurface, or sprinkler-irrigation methods. Surface irrigation is normally used only where the land has been graded so that uniform slopes exist. Land grading is not necessary for other methods. Each method includes several variations, only the more common of which are considered here.

Surface irrigation systems are usually classed as either flood or furrow systems. In the flood system, water is applied at the edge of a field and allowed to move over the entire surface to the opposite side of the field. Grain and forage crops are quite often irrigated by flood techniques. The furrow system is used for row crops such as corn (maize), cotton, sugar beets, and potatoes. Furrows are plowed between crop rows and the water is run in the furrows. In either type of surface irrigation systems, waste-water ditches at the lower edge of the fields permit excess water to be removed for use elsewhere and to prevent waterlogging.

Subirrigation is a less common method. An impermeable layer must be located below, but near, the root zone of the crop so that water is trapped in the root zone. If this condition exists, water is applied to the soil through tile drains or ditches.

In recent years sprinklers have been used increasingly to irrigate agricultural land. Little or no preparation is needed, application rates can be controlled, and the system may be used for frost protection and the application of chemicals. Sprinklers range from those that apply water in the form of a mist to those that apply an inch or more per hour.

Evaporation and seepage control.

Various techniques have been tried to reduce losses of irrigation water. Two major sources of loss, particularly from surface supplies and surface systems, are evaporation and seepage from reservoirs and canals. Many studies have been made of techniques to suppress evaporation. One of the more promising appears to be application of a special alcohol film on the surface, which retards evaporation by about 30 percent and does not reduce the quality of the water. The primary problem in its use is that it is fragile; a strong wind can blow it apart and expose the water to evaporation.

Seepage has largely been controlled by lining main and distribution channels with impervious material, typically concrete. Other materials used are asphalt and plastic film, though plastic tends to deteriorate if it is exposed to sunlight.

Typical systems.

The typical surface irrigation system utilizes a publicly developed water supply--*e.g.,* a river-basin reservoir. The public project also constructs the main canals to take water from the reservoir to the agricultural land. In general the canals flow by gravity, but lift stations are often required. Supply and field canals are used to bring the water to the individual field, where it is applied to the land either by furrow or by flooding method.

Until recently most sprinkler-irrigation systems depended on privately developed water supplies, but many modern sprinkler systems have been able to draw on public water supplies. In either case, a pump is required to pump water from a large (1,000 gallons, or 3,785 litres, per minute and larger) well or a supply canal. The water goes into the system main and thence to a sprinkler unit. Many automatic or semiautomatic moving sprinkler systems travel over the field applying water. Two common units are the so-called centre pivot and the travelling sprinkler. The centre-pivot unit is anchored at the centre of the field; a long lateral (arm) with sprinklers mounted on it sweeps the field in a circle. The system has the disadvantage of missing the corners of a square field. A travelling sprinkler is mounted on a trailer and propelled across the field in a lane that has been left unplanted. The unit drags a flexible hose connected to the main supply line. When it reaches the end of the lane, it is automatically shut off and can be moved to the next lane. Despite some shortcomings, all sprinkler systems are effective in applying a controlled amount of water at a high level of efficiency with a minimum of labour.

Primary tillage equipment.

Equipment used to break and loosen soil for a depth of six to 36 inches (15 to 90 centimetres) may be called primary tillage equipment. It includes moldboard, disk, rotary, chisel, and subsoil plows. (see also *Index*: farm machinery)

The moldboard plow is adapted to the breaking of many soil types. It is well suited for turning under and covering crop residues. There are hundreds of different designs, each intended to function best in performing certain tasks in specified soils. The part that breaks the soil is called the bottom or base; it is composed of the share, the landside, and the moldboard.

When a bottom turns the soil, it cuts a trench, or furrow, throwing to one side a ribbon of soil that is called the furrow slice. When plowing is started in the middle of a strip of land, a furrow is plowed across the field; on the return trip, a furrow slice is lapped over the first slice. This leaves a slightly higher ridge than the second, third, and other slices. The ridge is called a back furrow. When two strips of land are finished, the last furrows cut leave a trench about twice the width of one bottom, called a dead furrow. When land is broken by continuous lapping of furrows, it is called flat broken. If land is broken in alternate back furrows and dead furrows, it is said to be bedded or listed.

Different soils require different-shaped moldboards in order to give the same degree of pulverization of the soil. Thus, moldboards are divided into several different classes, including stubble, general-purpose, general-purpose for clay and stiff-sod soil, slat, blackland, and chilled general-purpose. The blackland bottom is used, for example, in areas in which the soil does not scour easily; that is, where the soil does not leave the surface of the emerging plow clean and polished.

The share is the cutting edge of the moldboard plow. Its configuration is related to soil type, particularly in the down suction, or concavity, of its lower surface. Generally, three degrees of down suction are recognized: regular for light soil, deep for ordinary dry soil, and double-deep for clay and gravelly soils. In addition, the share has horizontal suction, which is the amount its point is bent out of line with the landside. Down suction causes the plow to penetrate to proper depth when pulled forward, while horizontal suction causes the plow to create the desired width of furrow.

Moldboard-plow bottom sizes refer to width between share wing and the landside. Tractor-plow sizes generally range from 10 to 18 inches (25 to 45 centimetres), although larger, special-purpose types exist. (see also *Index*: tractor)

On modern mechanized farms, plow bottoms are connected to tractors either as trailing implements or integrally. One or more bottoms may be so attached. They are found paired right and left occasionally (two-way), with the advantage of throwing the furrow slice in a constant direction as the turns are made. A variation is the middlebreaker, or lister, which is a bottom equipped with both right- and left-handed moldboards.

The disk plow employs round, concave disks of hardened steel, sharpened and sometimes serrated on the edge, with diameters ranging from 20 to 38 inches (50 to 95 centimetres). It reduces friction by making a rolling bottom in place of a sliding one. Its draft is about the same as that of the moldboard plow. The disk plow works to advantage in situations where the moldboard will not, as in sticky nonscouring soils; in fields with a plow sole; in dry, hard ground; in peat soils; and for deep plowing. The disk-plow bottom is usually equipped with a scraper that aids in pulverizing the furrow slice. Disk plows are either trailed or mounted integrally on a tractor.

The rotary plow's essential feature is a set of knives or tines rotated on a shaft by a power source. The knives chop the soil up and throw it against a hood that covers the knife set. These machines can create good seedbeds, but their high cost and extra power requirement have limited general adoption, except for the small garden tractor.

The chisel plow is equipped with narrow, double-ended shovels, or chisel points, mounted on long shanks. These points rip through the soil and stir it but do not invert and pulverize as well as the moldboard and disk plows. The chisel plow is often used to loosen hard, dry soils prior to using regular plows; it is also useful for shattering plow sole.

Subsoil plows are similar in principle but are much larger, since they are used to penetrate soil to depths of 20 to 36 inches (50 to 90 centimetres). Tractors of 60 to 85 horsepower are required to pull a single subsoil point through a hard soil at a depth of 36 inches. These plows are sometimes equipped with a torpedo-shaped attachment for making subsurface drainage channels.

IRRIGATION

. Irrigation is the artificial supply of water to agricultural land. It is practiced by more than half the farmers in the world because they need more water for their crops than is available from rainfall. Irrigation projects must also allow for removal of excess water. Modern irrigation and the associated practice of drainage, together with the application of fertilizers and mechanization, have resulted in an unprecedented increase in farm productivity.

Fundamental Needs

Irrigation is required in crop raising wherever precipitation, both rainfall and snow, amounts to less than 10 inches (25 centimeters) a year. In regions with an annual precipitation of only 10 to 20 inches (25 to 50 centimeters), some crops may be grown by dry-farming methods, but larger and more dependable yields can be obtained through irrigation. Even in regions with adequate annual rainfall, irrigation may be necessary if the seasonal distribution is such that a dry period comes during the growing season. This occurs in areas that have the so-called Mediterranean climate--as in southern California and much of Italy--in which winters are rainy and summers dry. In parts of India and China, heavy monsoon rains fall in summer, but crops grown before the rains begin each year must be irrigated. Supplemental irrigation is also desirable in regions that are subject to short droughts even though the total rainfall during the growing season may be adequate.

If water is available at higher elevations, it can be conveyed to the irrigated land in open canals by the force of gravity. If the land to be irrigated is at a higher elevation than available water, lifting devices or pumps must be employed.

Water Supply

The most important element in any irrigation system is a dependable water supply. Most of the world's major irrigation systems receive water from great rivers that have their tributaries in snow-clad or rain-swept mountains. Among these rivers are the Nile in Egypt, the Indus in Pakistan, the Ganges in India, the Huang He (Yellow River) in China, the Syr Darya in Kazakhstan, the Amu Darya in Uzbekistan and Turkmenistan, and the Colorado, Columbia, and Missouri in the United States. Groundwater from deep wells is also used for irrigation, especially in desert countries such as Israel, Kuwait, and Saudi Arabia.

Generally the need for irrigation water is highest in the dry season when river flows are lowest. To ensure continuous supply, water must be stored on a seasonal and sometimes annual basis. By erecting a dam, an artificial lake, or reservoir, is created from which water can be released as required. Some reservoirs are capable of storing billions of gallons of water. Large dams and the associated reservoirs are often built for multipurpose use--irrigation, flood control, hydroelectric power generation, municipal and industrial water supply, and recreation. Systems of dams and reservoirs along a river and its tributaries are developed with the purpose of providing comprehensive and integrated water resources management in an entire basin. (See also Dam.)

Distribution

A modern large-scale irrigation system consists of the main dam and a network of diversion structures to distribute the water to where it is needed. Such structures include canals, pumping stations, and barrages. The water flows from the reservoir into a main canal that conveys water to the irrigation sites. The canal usually runs downhill, so the water flows by gravity. If the land does not slope properly for gravity flow, pumping stations must be built.

Through a smaller dam, or barrage, water is diverted from the main canal into a system of permanent ditches called laterals, which distribute it throughout the irrigated area. These laterals are mostly earthen ditches, and they may lose a considerable amount of water from evaporation and seepage. Losses from seepage can be prevented by watertight linings of such materials as asphalt, bentonite, or plastic foil. Evaporation losses can be eliminated if the ditches are replaced by pipe or tubing. This has an additional advantage of reducing the loss of cropland to ditches.

From the ditches or tubing, water is distributed to the fields by secondary or field ditches that may be temporary. To control the flow from the laterals into the field ditches, regulating closures called headgates are installed, while checks, or temporary regulating fixtures of metal or wood, lead the water from the field ditches onto the irrigated plots.

Distribution of irrigation water by pipelines--permanent or portable--is becoming more frequent. A permanent pipeline is usually of buried concrete, while portable systems use metal or plastic tubing. The main advantage of pipelines is that evaporation and seepage losses are eliminated, and the water can be conveyed under pressure as well as by gravity. They also are not troubled by the growth of algae. Widespread application of pipeline distribution systems, however, has not yet taken place because of their high cost.

Methods

Methods of irrigation depend on local conditions, including topography, crops to be irrigated, the nature and location of the water supply, and drainage characteristics of the soil. For these reasons modern irrigation methods vary widely, but they fall into one of five general categories: flooding, furrow irrigation, subirrigation, sprinkling, and drip irrigation.

Flooding. In the flooding method water covers the surface of the irrigation plot continuously and is contained there by small dikes or ridges. The fields to be irrigated are usually divided into smaller basins. Water is released from field ditches through siphons or by cutting temporary gaps through the earthen ridge of secondary ditches. After filling a basin with water, the farmer removes the siphons or closes the gap and repeats the procedure at the next basin.

Furrow irrigation. Many crops are irrigated by furrows, which are ditches between ridges on which the crops are planted. The water, coming from the laterals, is admitted to each furrow by cutting away a small earthen dike, thus opening a gap. When the water in each furrow has reached the desired level, the supply is cut off by reclosing the dike. Water seeps into the soil and feeds the roots of the plants. Compared to flooding, this method is more expensive to build and to operate. It can be justified, however, for high-value crops such as vegetables.

Subirrigation. If soil conditions are favorable, and the groundwater table is near the surface, subirrigation, or underbed irrigation, is used. Here water is delivered to the field in ditches and allowed to seep into the ground to maintain the desired groundwater level to feed the roots of plants. Compared with the flooding method, the amount of irrigation water is reduced significantly, but subirrigation also requires water of good quality and with low salt content. This approach is effective for delicate plants such as strawberries, small fruits, and vegetables because it keeps the tops of the plants dry and helps to prevent spoilage through rot or mildew.

Sprinkling. The sprinkler method is in some ways the most convenient and efficient irrigation system. Most types of sprinklers require piping and pumps. The water can be placed exactly where it is needed, and the flow rate can be regulated more accurately than in other systems. Sprinklers can also be used effectively on rough and hilly land without smoothing and grading. There are several types of sprinklers, some much like lawn sprinklers. Units can be portable, permanent, or semipermanent.

Rotary sprinkler systems are widely used in the United States. They consist of sprinklers mounted on a radial pipeline supported by towers. The towers are mounted on two wheels or small trucks for movement across a field. The pipeline is slowly rotated about a pivot by electric motors at each tower or, in self-propelled systems, by water pressure actuators. A single system can irrigate an area of 24 to 260 acres (10 to 105 hectares).

Drip irrigation. In drip, or trickle, irrigation, which was developed in Israel, a perforated plastic pipe is laid on the ground. The perforations are designed to release a controlled amount of water near the roots of plants. The method minimizes water losses due to both evaporation and deep seepage below the root level. It is practiced mainly in areas where water supplies are limited.

Drainage

Drainage, or the removal of excess surface and groundwater from irrigated land, is as important as the application of water. Too much water in the soil caused by overirrigation and the lack of adequate drainage results in an increasing buildup of salts and in waterlogging. The accumulation of salts, called salination, occurs because plants absorb water but leave the salts dissolved in it behind. Also, unless an effective drainage system is constructed, the groundwater table under the irrigation field gradually rises and may eventually reach the root zone, thus inhibiting plant growth.

The concentration of salts in water is harmful to some plants if it exceeds .09 ounce per gallon (700 milligrams per liter), and it is injurious to almost all plants if it reaches .26 ounce per gallon (2,000 milligrams per liter). As the water table rises nearer the surface and evaporation increases salt content, severe problems may eventually develop even if the irrigation water has a low salt content.

In some early large irrigation projects, mostly in arid and semiarid regions, little if any attention was paid to drainage. In some cases the results were catastrophic. It is estimated that in the Punjab in India and Pakistan more than 100,000 acres (40,000 hectares) of land are destroyed by salination and waterlogging every year. On a slightly lesser scale, similar problems have developed in China, Central Asia, Iraq, and in the southwestern United States.

To prevent such problems, effective drainage systems are required to remove excess surface water and to keep the groundwater level below the root zone. Surface water is removed by deep ditches along the irrigated areas, while groundwater collection and removal are accomplished either by laying porous tile drains underground at a depth of 10 to 15 feet (3 to 5 meters) or by a system of pumped drainage wells.

North America

United States. In the early 1990s more than 55 million acres (22 million hectares) of land were under irrigation in the United States. Of this total more than 90 percent was in Arkansas, Louisiana, Florida, and in 17 western states.

The great projects in the western United States are almost all multipurpose; irrigation is only one of the reasons for their construction. For example, the enormous Hoover Dam is the key structure in the development of the Colorado River in the Pacific Southwest. The system furnishes electric power and light for southern California, water for Los Angeles and surrounding cities, irrigation for hundreds of thousands of acres of desert, and a huge recreation area at the Lake Mead reservoir. The system also includes the All-American Canal that supplies irrigation water to the Imperial and Coachella valleys in southern California and the Yuma project in both Arizona and California. Other major systems in the West include the Central Valley project in California and the Grand Coulee Dam and its reservoir on the Columbia River in north-central Washington.

The Pick-Sloan Missouri Basin Program was authorized in 1944 for the comprehensive and multipurpose development of water resources of the Missouri River and its tributaries. The project includes flood control, navigation, hydroelectric energy generation, and the irrigation of more than 3 million acres (1.2 million hectares) and supplemental water supply to nearly 700,000 acres (280,000 hectares). The program incorporates 41 units in ten tributary river basins and is the most comprehensive and largest system developed after World War II.

Canada. Most of the irrigation projects in Canada are in the Prairie region, where rainfall is light and droughts are frequent. Irrigation works have been developed by farmers and other water users, by railroads and other commercial organizations, and by provincial governments. Passage of the Prairie Farm Rehabilitation Act of 1935 brought the dominion government into irrigation, sharing costs of large projects with the provinces and water users.

There are several major projects in western Canada. In southern Alberta are the St. Mary-Milk River, the Bow River, and the Eastern Irrigation District projects. Saskatchewan has the South Saskatchewan River development project, and Manitoba has the Oak Lake project. Other systems have been developed in central British Columbia.

Mexico. Irrigation in Mexico has grown in the last half of the 20th century to about 12 million acres (4.9 million hectares) of cultivated land. The Chicoasen multipurpose project on the Grijalva River is the most ambitious project in Mexico. In addition to generating electricity, it provides irrigation for more than 1 million acres (400,000 hectares).

The World's Great Irrigated Areas

In the early 1990s the total area of irrigated land in the world was estimated to be more than 400 million acres (162 million hectares). Approximately 70 percent is in Asia, 12 percent in the United States, 10 percent in Africa, and the remainder in Europe, South America, and Australia.

China. The multipurpose San Men project on the Huang He in China is the most ambitious project in Asia. In addition to irrigating more than 3 million acres (1.2 million hectares) of land, the power plant at the San Men Dam generates electricity and provides flood control. Another major project in China is the Miyun Dam on the Yangtze River, which provides water to irrigate about 1 million acres (400,000 hectares) of cultivated land.

India. Twenty-five percent of the cultivated land in India is under irrigation. The largest site, the Bhakra-Nangal project, receives water from the reservoir of Sutley Dam at Bhakra and Nangal Dam in Punjab. It irrigates more than 2 million acres (800,000 hectares) but has a capacity to expand. Also in India is the Nagarjunarsagar irrigation project in Andra Pradesh, which includes a dam at Nandikonda on the Kistra River. The project provides water for irrigation of another 2 million acres (800,000 hectares).

Pakistan. In Pakistan more than 50 percent of the cultivated land is under irrigation. The Mangla Dam on the Jhelum River produces hydroelectric energy and provides water for the irrigation of 3 million acres (1.2 million hectares). The Tarbela Dam, built on the Indus River, produces hydroelectric energy and will irrigate 4 million acres (1.6 million hectares) at full capacity.

Europe. In Europe the major irrigation projects are located in the south, primarily in Italy (7 million acres [2.8 million hectares]), France (6.2 million acres [2.5 million hectares]), Spain (5 million acres [2 million hectares]), and Bulgaria (2 million acres [800,000 hectares]). The individual projects are small compared to those in Asia. The largest one is in Lower Provence, France, with a major dam at Castillon on the Verdon River. The project includes about 600,000 acres (240,000 hectares) of irrigated area.

Central Asia. More than 50 percent of the land under irrigation in Central Asia is in Kazakhstan, Uzbekistan, and Tajikistan. The Syr Darya and the Amu Darya and their tributaries provide most of the water. Large dams on the Vakhsh River at Nurek and Rogun produce electricity and provide irrigation for 2 million acres (800,000 hectares).

Egypt. Irrigation in Egypt depends largely on the Nile River. The main system is controlled by the Aswan High Dam, which produces electricity and provides water for irrigation of 2.7 million acres (1.1 million hectares).

Australia. Almost 3 million acres (1.2 million hectares) of cultivated land are under irrigation in Australia. Major projects are in the southeastern part of the country along the Murray River and its tributaries--the Darling, Murrumbidgee, and Goulburn rivers. The irrigation pattern in Australia is characterized by centralized land and water allocations, as 90 percent of the irrigated projects have been built and are controlled by the federal government.

History

The Egyptians first used irrigation techniques in about 5000 BC. One of their first major irrigation projects was built in about 3100 BC during the reign of Menes, founder of the 1st dynasty. Ruins of elaborate irrigation projects built 2,000 to 4,000 years ago can still be found in many countries of the Middle East. The Marib Dam in Yemen, built in about 500 BC to store water for a large irrigation system, was in operation for more than 1,000 years. A large irrigation project in the Sichuan province of China dates to the 3rd century BC and is still in use. Irrigated agriculture flourished in the Western Hemisphere more than 2,000 years ago. The Incas in Peru developed an advanced agricultural civilization based on irrigation. About AD 1200 the Hohokam Indians in Arizona constructed extensive systems. Ditches in the Salt River Valley of Arizona, built around 1400, are in use today.

Mormon settlers in Utah established the first large-scale United States irrigation project in 1847. As other settlers moved into the West, many irrigation works were built. The early ones were small and crude, but later associations of farmers and commercial firms built more sophisticated ones. By 1900 about 9.5 million acres (3.8 million hectares) were being irrigated.

In 1868 the federal government entered the field with the construction of works to provide water for the land on the Mojave Indian Reservation in Arizona. With the passage of the National Reclamation Act in 1902, the government began to finance projects that were too large for individuals, groups, or even states. Today most large irrigation projects are initiated and directed by national governments. [15]

Resources

People

Farm manager

Farmers

Can we offer accommodation to attract people?

Land

North American farms are at least 100 ha. Irish farms are smaller. Castle Organic Farm has ~ 30 acres (12 ha) of which half is in forestry and half under cultivation. Approximately 12 acres (5 ha) is propagation and cultivation the remainder is animals. If other inputs are available, principally people and equipment, then say 20 ha (50 acres) to start.

Consider putting land under forest.

Equipment

Required:

Tractor

Two-wheel cultivator (5 – 14 hp).

Plough (reversible), till (rotary tilling box)

Seeder

Brush weeder

Sheet layer

Flame weeder

Weights

Propagation sheds: 4x £600 ea, self construct. Propagation trays, tables. Heaters. Thermometers.

Materials

[15]Excerpted from *The Complete Reference Collection*.

Seeds

Plastic sheets

Paper sheets

SALES, MARKETING, DISTRIBUTION

Premarketing and Selling

Premarketing operations include washing, trimming, waxing, precooling, grading, prepackaging, and packaging. Vegetables often require washing after harvest to remove any adhering soil particles. Such vegetables as the beet, carrot, celery, lettuce, radish, spinach, and turnip are trimmed before washing to remove discoloured leaves or to cut back the green tops. Waxing of the cucumber, muskmelon, pepper, potato, sweet potato, and tomato gives the product a bright appearance and controls shrivelling through reduction of moisture loss. (see also *Index*: wax)

Precooling.

Precooling, the rapid removal of heat from freshly harvested vegetables, allows the grower to harvest produce at optimum maturity with greater assurance that it will reach the consumer at maximum quality. Precooling benefits the vegetable by slowing the natural deterioration that starts shortly after harvest, slowing the growth of decay organisms and reducing wilt by retarding water loss. The major precooling methods include hydrocooling, contact icing, vacuum cooling, and air cooling. In hydrocooling the vegetable is cooled by direct contact with cold water flowing through the packed containers and absorbing heat directly from the produce. In contact icing crushed ice is placed in the package or spread over a stack of packages to precool the contents. The vacuum cooling process produces rapid evaporation of a small quantity of water, lowering the temperature of the crop to the desired level. Air cooling involves the exposure of vegetables to cold air; the air must be as cold as possible for rapid cooling but not low enough to freeze the produce exposed to the direct air blast.

The preferred method of precooling varies according to the physical characteristics of the vegetable. Hydrocooling is recommended for the asparagus, beet, broccoli, carrot, cauliflower, celery, muskmelon, pea, radish, summer squash, and sweet corn (maize); cabbage, lettuce, and spinach are suited to vacuum cooling; air cooling is preferred for bean, cucumber, eggplant, pepper, and tomato. After the produce is precooled, it is desirable to maintain low temperature by shipping in refrigerator cars or trucks, by storing in cold-storage rooms, and by refrigeration in retail stores.

Grading.

Uniformity in size, shape, colour, and ripeness is of great importance in marketing any vegetable product, and can be secured through grading. The establishment of standard grades furnishes a basis of trade. Grade standards are based mainly on general appearance, size, trueness to type, and freedom from blemishes and defects.

Packaging.

Prepackaging, or consumer packaging, has become a highly organized practice, often employing elaborate equipment. The product is placed in bags made of transparent film, trays or cartons overwrapped with transparent film, or mesh or paper bags. The packaging of produce in consumer packages lends itself to self-service in retail stores. The production region is often the most satisfactory location for prepackaging, especially when a packaging centre serves a large vegetable-growing area.

Master containers for consumer packages are commonly made of paperboard. Cartons, bags, baskets, boxes, crates, and hampers of various kinds and sizes are all used in packaging vegetables for marketing. The type of container is selected to fit the kind of vegetable; it furnishes a convenient means for transport, loading, and stacking, with security and economy of space. Uniform product throughout the package is an important consideration in packing vegetables.

Selling.

Producers sell vegetables through various retail and wholesale practices. Retail sales are made directly to the consumer, often through roadside stands. Many growers sell most of their produce at wholesale to retail stores, to various types of buyers on local markets in nearby cities, or in regional markets. Growers located long distances from markets sell largely to wholesale dealers or jobbers. (see also *Index*: retailing, marketing)

Some growers have contracts with processors. Wholesale marketing arrangements are also made through auction markets in the producing regions and through cooperative organizations of producers. (W.A.W.)

Competition

Dibbles, Roisin Jenkins, Rye Valley, Golden Vale

Naturally Irish, …

NUMBERS

Potatoes

£ 0.25 - £ 0.30 /lb ~ £670 /tonne

25 tonnes /ha 50% outgrade 12.5 tonnes /ha or 5 tonnes /acre

	£ 8,400 /ha or £ 3,350 /acre
seed/chitting 2.8 tone / ha at £ 200 /tonne	£ 560 /ha
fungicide x2	£ 40
labour	£1,000
box and transport £ 20/tonne ~	£450
packaging	£ 160
gross contribution	£ 6,190 /ha

APPENDIX

GLOSSARY

Bushel

BACKUP

Peanuts (Arachis hypogaea). Peanuts are grown in warm temperate or subtropical areas throughout the world, and the major world crops are grown in Africa, Asia, and Indonesia. India, with 6.6 million tons (6 million metric tons) in 1981, and China with 3.9 million tons (3.5 million metric tons) are the largest producers of peanuts. The United States harvests more than 1.4 million tons (1.3 million metric tons) each year, but this is less than 10 percent of the world's supply. The largest peanut crops in the United States come from the South, particularly Georgia and Alabama. The annual production of peanuts in the United States is often greater than that of beans and peas combined. Some African countries (Sudan, Nigeria, and Senegal), as well as Indonesia, produce approximately 660,000 to 1 million tons (0.6 to 0.9 million metric tons) per year.

Peanuts are high in protein (about one fourth of their volume) and fatty oils (about one half). They are also high in calories. In contrast to soybeans, which are used primarily as feed for animals, peanuts are consumed directly as food by humans in the form of the nuts themselves or as peanut butter. Peanut oil is a highly versatile product, being used in a variety of food and industrial products.

A peanut plant has yellow flowers that appear on the stem. But after the flowers are fertilized, the developing pods and seeds they produce are pushed into the soil by an attachment called a "peg" that connects to the main stem. The seeds are the edible portion of the plant. From two to four seeds are encased in a pod, which develops underground for four or five months before they are harvested.

Alfalfa (Medicago sativa). The oldest known plant used for livestock feed is alfalfa, a legume that is known to have been grown as a crop earlier than 1000 BC in the Middle East. Today alfalfa, which is also called lucerne, is grown widely in the Western Hemisphere, Europe, and Australia. The United States is the world's largest producer of alfalfa as a feed crop, with the major supplies coming from the midwestern states and California.

Although alfalfa is sometimes used for cattle grazing, it is grown primarily for harvesting as hay or silage. Alfalfa hay, a major feed source for cattle and sheep, is obtained after the plants have been cut and dried in the fields. Silage, made from freshly cut alfalfa plants, is a higher nutrient source for livestock than hay. Silage is not dried and must be stored in silos, whereas baled hay can be stored more readily in any sheltered area and does not require immediate attention. Alfalfa can be ground into meal and be used for poultry as well as livestock. [16]

Organic Farming General Information

Introduction

Organic production is not an enterprise in the normal sense, but rather a production system.

Each individual unit develops its own system based on many normal production practices, which are then guided and controlled by approved organic standards.

These standards have been developed to provide organic producers with clear rules as to how organic food should be produced to meet consumers' demands.

Certification

Food sold as organic anywhere in the EU must be certified as produced under an approved organic standard.

This certification is the consumers' guarantee that food has been produced to approved organic standards.

It does not give any guarantee as to, for example, freedom from pesticide residues, nutritional value or any other 'quality'.

EC organic legislation

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EC legislation controls the production of organic food within the EU, as well as the importation of organic food from outside the EU.

UKROFS

The United Kingdom Register of Organic Food Standards (UKROFS) is the government body set up to ensure that organic food produced in the UK meets the standards set by EC legislation, as well as UK standards.

UKROFS sets basic UK standards and also approves independent certification bodies and their standards as meeting UK and hence EC organic standards.

The information in the series of leaflets, of which this is the first, is geared to meeting UKROFS standards, but independent standards may differ.

Certification bodies

Within the UK, UKROFS itself, and certification bodies approved by it, carry out certification of producers, processors, packers etc of organic food.

Within Northern Ireland the certification bodies actively carrying out certification at present are the :

Soil Association Tel: 01179 142400

Irish Organic Farmers and Growers Association (IOFGA) Tel: 00 353 1 8307996

Bio-Dynamic Agricultural Association (BDAA) Tel: 01387 730217

Inspection

In order to become a registered organic producer, a farm or holding must undergo an initial inspection based on previously submitted information and records, plus an organic conversion plan.

Then, once initial certification and license have been granted, an annual inspection is carried out to renew the license.

Costs

Each certification body sets its own rates for inspection and licensing. These are in the region of £270 to £350 for the first year and from £150 to £800 plus VAT, depending on turnover, in each subsequent year.

Organic standards

The standards adopted by the various certification bodies all vary somewhat in how they apply UKROFS standards. In other words, any particular set of standards may have its own additional requirements over and above UKROFS standards.

It is therefore very important to choose a set of standards that meets your needs.

Changes in EC organic legislation

EC organic legislation is continually changing resulting in the continual development of national and independent organic standards in order to maintain their approved status.

As far as possible, the information contained in this series of leaflets attempts to anticipate important possible future changes in standards that will determine how organic systems will be implemented on producing units.

This will help ensure that an organic production system planned today will still be workable under future organic standards.

Conversion

Organic certification is not a simple one-off procedure.

Land has first to undergo a ‘conversion’ period during which food grown on it may not be sold as organic.

Crops and forage

In simple terms crops and forage grown on land which has been in conversion for at least one year may be classed as ‘in-conversion’.

After a second year of conversion, they may be classed as fully organic (also known as ‘symbol standard) when the certifying bodies' symbol or logo may be used as an identification mark indicating its organic status.

Livestock

Most livestock already on a unit at the start of conversion can never be sold as organic.

Milk from dairy cows and meat from the progeny of breeding stock can be sold as organic following the specified conversion periods.

In practice, it is likely to be at least three years before any organic livestock can be sold from a unit. The actual time span will depend on the type of livestock and the production system.

Conversion planning

A very important part of converting a unit to full organic status is a realistic conversion plan which allows conversion to proceed as rapidly as practicable.

A sound conversion plan will :

Produce a practical, balanced organic system

Minimise financial pressures during conversion

Steadily build producer confidence

Keeping records

Full records of all producing activities, inputs, purchases and sales must be kept and made available for the annual inspection.

Contractors

Contractors can be used in organic production providing that all organic standards are met.

Organic Production assistance

DANI offers prospective organic producers a package of assistance.

This includes :

Business management information and advice

Education and training

Conversion planning assistance

Marketing information and advice

Organic Aid Scheme information and advice

Organic Aid Scheme

DANI offers an organic aid scheme as an encouragement to conventional (non-organic) producers to convert to organic production.

Information on the scheme can be obtained from the contacts listed below.

Contacts for further information

Organic crops and horticulture

Adrian Saunders
Greenmount College, Antrim, BT41 4PU
Tel: 01232 701115
Mobile Tel: 07887 708807
email: organic.veg@dnet.co.uk

Organic livestock

Charlotte Moore
Greenmount College, Antrim, BT41 4PU
Tel: 01849 426752
Mobile Tel: 07887 708806
email: charlotte.moore@dani.gov.uk

Products

Legumes

The more than 18,000 kinds of plants belonging to the pea family (Leguminosae) are known as legumes. The Leguminosae is the third largest family of flowering plants, being exceeded in numbers of species only by the Compositae (sunflower family) and Orchidaceae (orchid family). The word legume means seed pod and refers to the case that encloses the seeds. The pods come in a variety of shapes, sizes, and textures and are sometimes used to distinguish between similar but different legumes.

Except for the grasses, legumes are the most important plants in the world from an economic standpoint. They are an important food source for humans (peas, beans, and peanuts) and livestock (alfalfa and clover). Legumes provide timber (black locust, rosewood), oils (soybeans), and dyes (indigo). [17]

There are three major subfamilies: Mimosoideae (acacia subfamily), Caesalpinoideae (bird-of-paradise subfamily), and Papilionoideae (bean subfamily). A fourth subfamily, Krameriodeae, with a single genus is also recognized by plant taxonomists[18].

Nitrogen Fixation

One of the unusual features of legumes is nitrogen fixation, a process characteristic of most legumes and found in few other plants. Nitrogen fixation is the obtaining of nitrogen, an essential nutrient for growth, from the atmosphere. Nearly all other green plants depend on nitrogen compounds in the soil to provide them with nitrogen. The nutrient is taken up directly by their roots.

For nitrogen fixation to occur, special soil bacteria (genus Rhizobium) must enter the root system of the legume through the tiny root hairs on each root. The bacteria then release enzymes that cause the root cells to divide so that a nodule is formed on the root. Obtaining energy from the legume, the bacteria living in these nodules take atmospheric nitrogen from the air in the soil and produce ammonia, a nitrogen compound. The ammonia is available to both bacteria and legume, which convert it into amino acids and other proteins essential for growth. An association in which both benefit from the relationship in a manner that neither could alone, is known as mutualism.

The importance of nitrogen fixation to agriculture has been recognized since early Roman times, though the process was not understood until the 19th century. Once the edible parts of a legume crop such as beans or peas have been harvested, the remainder can be plowed into the soil. There, as it deteriorates, it releases into the soil the non-atmospheric nitrogen it made from the nitrogen in the air. [19]

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Peas and Beans

The United States averages a harvest of about 1.1 million tons (1 million metric tons) of dry beans each year but less than 220,460 tons (200,000 metric tons) of dry peas. Both are cool temperate crops, and the highest production is in the northern states. Michigan is the highest producer of beans; Wisconsin and Washington grow the most peas. [20]

Pulses

The edible seeds of beans or peas are referred to as pulses, and many species are native to the tropics. Most are only distantly related to the common beans and peas that are produced commercially in temperate regions. A major deterrent to development of certain varieties is the lack of research to establish proper growing conditions and factors affecting production. For example, the Bambara groundnut (genus Voandzeia) of Africa is considered to be a hardier, more disease-resistant species than the peanut but was neglected as a food crop for many years. Most tropical regions have similar examples of unexploited pulses that could be important sources of protein and vitamins. [21]

Cereal

Production

Organic cereal production fits neatly into a planned rotation on an organic unit.

It is possible for a specialist cereal producer to grow organic cereals on an organic unit by renting the land. In this situation all other organic standards would still need to be implemented and the producer would have to register with a certification body.

It may also be possible to have a single field in organic crop production, providing it operates a suitable planned rotation, and organic grain can be adequately isolated from any other cereals grown on the unit.

Markets for organic cereals

Organic cereals have several main markets :

On the producing unit, for use as livestock feed

By supply agreement to another organic unit

On the free market – feed and bread/biscuit quality grain

It is likely that the first of these will be the main ‘market’ since the need for cereals on a livestock-based organic unit will take priority.

It may be possible to produce additional cereals for another organic unit or the open market.

However, in Northern Ireland, the possibilities of producing cereals as a main marketable product may be limited.

There are also markets for organic straw, though most will likely be used on producing units.

Nutrient provision

In an organic situation, provision of specific amounts of nutrients is not possible.

It is highly likely that organic cereal crops will be grown as break crops following a grass/clover ley and another more nutrient demanding crop.

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The grass/clover ley will provide significant quantities of nutrients, particularly nitrogen.

Manure may also be useful for a second cereal if supplies are available.

Rotations

There are two basic types of rotation that can be operated to include cereal production.

Rotations containing livestock

Rotations containing livestock and associated grass/clover leys are likely to be the main type of rotation in Northern Ireland.

As an example, in an eight-course rotation there should not be more than three crops in order to avoid reductions in soil fertility.

Cereals would fit into these as break crops.

Stockless rotations

Rotations that do not include livestock are possible and are known as stockless rotations.

Instead of grass/clover leys, legumes as green manures are included in the rotation as an organic matter/nitrogen source.

Their performance under Northern Ireland conditions is not known, and they are only likely to be suitable on good arable soils.

Green manures

Green manures, mainly legumes such as vetches and clovers, can be used to extend a rotation, thus allowing additional cereal crops to be grown.

Straw

The need for straw on livestock units strongly encourages cereal production in the rotation. At present, whilst supplies are limited, non-organic straw can be used.

Surplus straw, if available, does have a market in the organic sector.

Wheat straw of certain long-strawed varieties also has considerable value as thatching straw.

Undersowing

Undersowing with grass/clover is an excellent means of :

- Re-establishing leys
- Avoiding bare ground after cereals

However, combining very short-strawed cereal varieties can be difficult, and straw difficult to save, due to the undersown crop growing up into the cereal.

Choice of suitable cereal varieties then becomes important.

Winter or spring cereals

Spring cereals are most suited to organic production.

Winter cereals are less suitable due to difficulties with :

- Providing additional nutrients (top dressings) in the spring
- Weed control over winter
- Avoiding barley yellow dwarf virus
- Winter disease control
- Over winter pest control

Varieties

Most modern cereal varieties have short straw.

Avoid very short-strawed varieties if the crop is to be undersown

Choose varieties suited to lower input / fertility situations

Choose pest and disease resistant varieties

Weed control

No herbicides are allowed in organic production.

Weed control relies on :

Choosing fields with no major weed problems

Clean seed beds

Mechanical cultivations -specialised spring-tine harrows are available for weeding cereals.

Pest control

Pest problems are usually fairly intermittent in cereals. Since only a few specific pesticides are permitted, (mainly for aphid control), avoidance of potential problems is the key to successful pest control.

Pest control relies on :

Varietal resistance

Provision of habitats for pest predators eg grass strips and hedge bottoms.

Disease control

Few fungicides are allowed in organic production.

Disease control mainly relies on :

Rotations and field hygiene

Vigorous growth and varietal resistance.

Permitted fungicides

Only selected sulphur and copper-based fungicides are currently permitted, but may not be permitted in the future. When wishing to apply a fungicide three very important points should be noted :

Certification bodies vary in the fungicides which they permit

Only use proprietary products, as home-made formulations are not allowed under the Food and Environment Protection Act 1985 (FEPA) and the Control of Pesticides Regulations 1986 (COPR)

Routine fungicide application is not allowed

Harvesting and storage

No desiccants are allowed in organic cereal production.

Early maturing varieties should be chosen.

No grain preservatives are allowed.

Grain dryers and grain bins must be approved and allow isolation of organic crops from conventional crops.

The Wheat Plant

Wheat is an annual plant made up of roots, a stem, leaves, and the head, which is also called a spike. The roots can grow about 3 to 6 feet (90 to 180 centimeters) deep. The hollow stem has about six segments joined by nodes, each with an attached leaf. Wheat leaves may be short and wide or narrow and long. They are made up of a sheath, which surrounds the stem, and the leaf blade, which lies out flat so it can gather light. Each leaf is on the opposite side of the stem from the leaf above or below it. Some wheat varieties grow only 2 to 3 feet (61 to 91 centimeters) tall, while others may grow 5 feet (152 centimeters) tall. The shorter varieties are a more suitable food crop.

The head or spike is the part of the plant where the grain forms. The head is usually made up of a zigzag central axis along which are alternating spikelets-- each containing several flowers. The flowers are enclosed by protective structures called glumes. In some bearded varieties of wheat, the glumes have a long, slender bristle called an awn.

Fertilization begins about two days after the spike emerges from the sheath of the flag leaf. As the flowers open up, the antlers shed pollen that sticks to the stamen and germinates to grow into the ovary and fertilize the egg cell.

Wheat is self-pollinating, which means that it is fertilized by its own pollen. The grain starts to grow after fertilization. The time needed for the grain to grow and mature depends on such factors as temperature and rainfall. In much of the United States, this takes about one month.

The Wheat Kernel

The wheat kernel consists of a tiny plant called the embryo, or germ, which makes up about 3 percent of the weight of the kernel; the starchy endosperm; and the protective seed coat, or bran. The endosperm makes up about 83 percent of the weight of the kernel and is the food supply for the seedling when a seed germinates. When wheat is milled into flour, the bran and germ are removed. Flour is produced by grinding or rolling the endosperm into powder. [22]

Cruciferae

Cabbage, mustard, and their many relatives belong to the family Cruciferae (cross bearers). The name comes from the shape of the flowers. They have two separate petals and two sepals, which are petal-like parts, arranged in opposite pairs in the form of a Maltese cross. The flowers may be white, yellow, orange, lilac, or purple, arranged in loose clusters at the top of the stem. There are six stamens, which are male sex organs, two of them lower and shorter than the others. The seed pods usually consist of two outside walls, separated by a thin white partition.

Among the oldest of vegetables grown for human food is the cabbage. Homer, nearly 3,000 years ago, wrote in the 'Iliad' that Achilles washed cabbages. The wild ancestor of cabbage is native to the shores of the Mediterranean Sea. It also grows on the sea cliffs of Great Britain, where it was probably introduced by the Romans. Wild cabbage (*Brassica oleracea*) is a scraggly, starved-looking biennial plant with loose, narrow leaves, a thin stem, and whitish-yellow flowers. Of the many cultivated plants that have been developed from wild cabbage, some are raised as ornamental plants, some as fodder for livestock, and a great deal more as food for humans.

Brassica Oleracea

The best-known members of the cabbage group of vegetables include kale and collard; cauliflower and broccoli; common, or head, cabbage; brussels sprouts; and kohlrabi. These plants are all varieties, or cultivars, of *Brassica oleracea.*

The common, or head, cabbage has a compact head of leaves with only a few loose outer leaves around a central stem. The thick stalk extends about 8 inches (about 20 centimeters) underground.

[22] Excerpted from *The Complete Reference Collection*.

There are more than a hundred varieties of cabbage. Some have flattened heads; some are egg-shaped; some are perfectly round. The leaves may be smooth or wrinkled and range in color through various shades of green, gray-green, and magenta or red. Those with wrinkled leaves are often called Savoy cabbages.

The cultivated plants most nearly like the wild cabbage are kale and collard. They form no heads but spread their long, curving leaves outward from the stalk. The margins of kale leaves are wavy or frilled; those of collard are broader and smooth.

Cauliflower forms a head of tight, thickened white flowers that are eaten raw or cooked. The low-growing head is surrounded by large, spreading leaves. Broccoli is a variety of cauliflower with green, loosely clustered flowers that are eaten with the tender stalks.

Brussels sprout plants form many little cabbage-like heads called brussels sprouts about 1 to 2 inches (3 to 5 centimeters) in diameter along the tall, sturdy stem instead of one large head at the top. The top has spreading leaves. The sprouts ripen upward from the bottom of the stem.

The stem of the kohlrabi thickens to form an edible tuber 1 to 3 inches (about 3 to 8 centimeters) above the ground. The leaf stalks of the kohlrabi grow out of the tuber.

Species Related to Brassica Oleracea

Other agriculturally important species in the *Brassica* genus include many species of mustard, especially black, or brown, mustard (*B. nigra*); white, or yellow, mustard (*B. hirta*); and Indian, or brown, mustard (*B. juncea*). The mustards are tall, fast-growing biennial or annual plants cultivated in most parts of the world both for their pungent seeds, which are processed into commercial mustard spreads, and for their greens.

The seeds of the rape plant (*B. napus*) contain colza oil, which is used for fuel, in cooking, as a lubricant, and in soaps and synthetic rubber.

The turnip (*B. rapa*) and the Swedish turnip, or rutabaga (*B. napobrassica*), are hardy biennial plants cultivated for their fleshy roots and tender tops.

Chinese cabbage is the common name for two species of annual or biennial plants in the cabbage-mustard family that are popular in Chinese cookery. Both *B. chinensis,* known as pak-choi, and *B. pekinensis,* known as pe-tsai or celery cabbage, resemble romaine lettuce more than cabbages and have a peppery taste.

Related Genera

Other relatives of the cabbages and the mustards in the family Cruciferae include the radishes (*Raphanus sativus*). They have round or long roots, eaten as relishes or in salads. The coarser root of the horseradish (*Armoracia rusticana*) is processed into a condiment with a very strong, biting flavor. Watercress (*Nasturtium officinale*) is a water plant whose shoots take root in mud or trail in water. Its leaves have a sharp, peppery flavor and are sometimes used in salads. [23]

Potato

Constituents

The tuber is composed mainly of starch, which affords animal heat and promotes fatness, but the proportion of muscle-forming food is very small - it is said that 10 1/2 lb. of the tubers are only equal in value to 1 lb. of meat. The raw juice of the Potato contains no alkaloid, the chief ingredient being potash salts, which are present in large quantity. The tuber also contains a certain amount of citric acid - which, like Potash, is antiscorbutic - and phosphoric acid, yielding phosphorus in a quantity less only than that afforded by the apple and by wheat.

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[23]Excerpted from *The Complete Reference Collection*.

It is of paramount importance that the valuable potash salts should be retained by the Potato during cooking. If peeled and then boiled, the tubers lose as much as 33 per cent of potash and 23 per cent of phosphoric acid, and should, therefore, invariably be boiled or steamed with their coats on. Too much stress cannot be laid on this point. Peeled potatoes have lost half their food-value in the water in which they have been boiled.

Potato Production

Organic potato production fits neatly into a planned rotation on an organic unit.

It is possible for a specialist potato producer to grow organic potatoes on an organic unit by renting the land. In this situation all other organic standards would still need to be implemented and the producer would have to register with a certification body.

It may also be possible to have a single field in organic crop production, providing it operates a suitable planned rotation, and organic potatoes can be adequately isolated from any other potatoes grown on the unit.

Organic potato production is of interest to many producers as the crop :

- Is in demand from consumers
- Can be profitable
- Can be a break crop from grass in the rotation
- Requires cultivations which help control weeds

Organic potato production has a number of challenges which must be tackled :

- Providing adequate nutrients
- Preventing potato blight
- Weed control

Organic producers have to rely on alternative approaches rather than artificial fertilisers and synthetic chemical herbicides and fungicides.

Nutrient provision

In an organic situation, provision of specific amounts of nutrients is not generally possible.

It is highly likely that an organic potato crop will be grown as the break crop following a grass/clover ley which will provide significant quantities of nutrients, particularly nitrogen.

Alternatively, potatoes can be grown following a legume crop or a leguminous green manure.

Because potatoes require a large quantity of nutrients, manure should be applied at this point in the rotation.

Preventing potato blight

Potato blight cannot be cured and, particularly in an organic situation, avoidance is definitely the best policy.

Certain fungicides are currently permitted, but must not be applied on a routine basis.

Avoiding blight

blight is not generally a problem with early harvested, early varieties.

plant early varieties if suitable/possible

plant healthy, blight-free seed

select varieties with high blight resistance listen for, and pay attention to, blight warnings

if the blight pressure is high apply a permitted fungicide

Weed control

After blight prevention, weed control is potentially the most troublesome field operation facing organic potato producers. As no herbicides are permitted, weed control is carried out by :

choosing fields with no major weed problems

flame weeding of weed seedlings before the potato tops emerge - this can be expensive

mechanical weed control just before tops meet between rows

limited hand weeding of any large invasive weeds

Pest control

Pest problems are usually fairly intermittent in potatoes. Since only a few specific pesticides are permitted, (mainly for aphid control), avoidance of potential problems is the key to successful pest control.

Permitted fungicides

Only selected sulphur and copper-based fungicides are currently permitted, but may not be permitted in the future. When wishing to apply a fungicide three very important points should be noted :

- Certification bodies vary in the fungicides which they permit
- Only use proprietary products, as home-made formulations are not allowed under the Food and Environment Protection Act 1985 (FEPA) and the Control of Pesticides Regulations 1986 (COPR)
- Routine fungicide application is not allowed
- Under Northern Ireland conditions organic potato producers frequently have to remove potato haulms early because of foliage blight. This reduces yield but helps to avoid tuber blight.

Consumer requirements

A common misconception is that consumers of organic produce will accept a lower quality of produce, because it is organic, compared with conventionally grown produce.

This is often not true and potatoes presented for sale should be of the highest quality, and on a par (visually) with conventional produce.

Consumers, initially at least, often buy potatoes based on appearance, and placing poor quality produce on sale will have an adverse impact on consumer acceptability and purchase. It may also damage the prospects for future sales however good the actual or apparent cooking quality.

Selecting potato varieties

In selecting varieties for organic production there are two simple rules :

Grow varieties suited to organic production

and

Grow varieties which best suit the intended market

As with all organic produce, grow what will sell, not what you want to sell.

Seed potatoes

Organic potato crops must be grown from organically produced seed potatoes.

These are now becoming easier to obtain, though at present they will probably come from Scotland or the Netherlands.

When ordering seed :

Order seed early (whilst the seed crop is growing) to ensure supplies

Plant the highest class of seed you can afford, preferably a higher Super Elite (SE) class

Seed potato production

There is clearly potential for organic seed potato production in Northern Ireland since organic ware producers require organic seed.

It is, however, a specialised task.

Haulm destruction and harvesting

Haulm removal

Only physical means of haulm removal are permitted. These include :

- flailing (haulm chopping)
- haulm pulling
- flaming
- Chemical methods of desiccation or application of sulphuric acid are not permitted.

Tomato

South America is the home of the tomato, a fruit that is commonly called a vegetable. Indians of the Andes Mountains grew it for food in prehistoric times. Migrations carried it to Mexico more than 3,000 years ago. The Spaniards introduced the tomato to Europe in the 16th century. It was first grown in Italy about 1550.

Tomatoes belong to the same family as the deadly nightshade. In the United States they were thought poisonous until the 19th century. Tomatoes are now cultivated in all temperate regions of the world. They have more uses and are canned in greater quantities than any vegetable.

Vegetables & Fruit Production - Overview

Fruit and vegetables are currently the most common organic produce available. Around 70% of those available are imported, suggesting that there is considerable scope for home production.

Organic vegetable production is relatively intensive compared with many other organic enterprises, and particular care is required in implementing a practical production system.

There are three ways in which organic vegetable production can be implemented :

As field crops within a rotation on an organic unit with other organic enterprises

As a market garden enterprise within a rotation on an organic unit with other organic enterprises

As a smaller scale market garden system on its own

In any of these situations protected cropping under polythene tunnels is an additional option.

Challenges in organic vegetable production

There are four main areas which present the biggest challenge to organic vegetable production :

Building and maintaining soil fertility

Weed control

Maximising the production season

Successional cropping

Careful planning is required in order to develop practical systems and optimise returns.

A realistic assessment of the labour and time resources needed, and available, must be taken into account during planning.

Soil fertility and management

Building and maintaining soil fertility are high priority and vegetable units should aim to be largely self-sufficient in providing crop nutrients.

Manures

If the vegetable unit is part of a larger organic unit, there may be manure available for the vegetables.

At present, non-organic manure may be brought in to *supplement* on-unit resources, but the source and quantity will require prior approval from your certification body. Brought-in manure will also require composting for several months prior to use.

A high reliance on brought-in manure will not be allowed, nor will manures (eg pig and poultry) from intensive livestock units.

Green manures & legumes

It is imperative that vegetable producers, particular in market-garden units, make maximum use of green manures for providing nutrients and organic matter, and as part of the weed control programme.

In practice this means that within the cropping rotation green manures should effectively account for 25% of the rotation.

This will include legumes for nitrogen generation, short-term green manures as cover crops, green manure mulches and over-wintering green manures.

Growing legumes for nitrogen generation is probably the most important aspect of green manuring.

Rotations

Apart from being part of the weed, pest and disease prevention regime, carefully planned vegetable rotations, including green manures, are essential for exploiting soil nutrients at different depths and for balancing nutrient use with replenishment.

Garden-type vegetable rotations should be incorporated into the production plan, with longer rotations being preferable to shorter ones.

Weed control

Since there are no herbicides available to organic growers, weed control is one area that can cause major problems for organic vegetable producers.

Weed control can be effected by a combination of :

Correct choice of beds or drills to suit the crops grown

Proper rotational practice

Green manures and cover crops

Crop sowing dates

Mechanical cultivations and hand weeding, including hoeing

Specialist weeding equipment - eg brush weeder

Flame weeding and stale seedbed techniques

Appropriate cover crops and organic matter-based mulches

Plastic-type mulches

It is vital that provision/capital for equipment and/or labour requirements is included in plans for producing organic vegetables.

Specialist equipment does exist, but as it can be expensive, sharing of equipment can reduce costs.

Pest control

Important means of pest control include :

Proper rotational practice

Sowing and planting dates targeted to minimise competition from weeds

Provision of suitable habitats for pest predators

Barriers that deny pests access to crops

Only very few pesticides are available to organic growers, but an increasing range of biological control agents is being developed, mostly for use in polythene tunnels.

Disease control

Disease control is based on provision of a soil and environment that produce strong, vigorous plants and which discourage disease.

Disease control measures include :

Proper rotational practice and use of resistant varieties

Biological diversity

Companion plants - plants which attract a pest's predators or repel the pests

Good field hygiene

These are *supplemented* by permitted fungicides.

Maximising the production season

Many organic vegetable producers initially concentrate on summer vegetable crops. This is the easiest option, but does mean that customers cannot be supplied during the winter months, except by importing and selling produce from elsewhere.

Growers must develop systems for producing crops all year round, both in the field and under protection in order to maintain continuity of supply.

An addition to this would be provision of storage facilities, possibly shared by several producers.

Protected cropping

Polythene tunnels are common on many organic vegetable units. They are used for :

Summer salads and tender vegetables

Extending the growing season both in the spring and autumn/winter

Plant propagation

Winter cropping

Basic organic production principles are similar to field grown crops.

Soft fruit

Soft fruit such as strawberries, gooseberries, raspberries and currants are increasingly popular on organic units.

Supplies of organic plants (required by EU standards) are also increasing.

Production methods are continually improving as more producers come on stream, though some problems, such as gooseberry sawfly control, still require to be overcome.

An additional difficulty with soft fruit is obtaining pickers at harvest time.

Top fruit

Top fruit production, mainly apples and pears, is at a very early stage of development in the UK, and little firm information is available.

What is known is that :

Choice of variety is important

Many non-organic varieties widely sold in supermarkets are not easy to grow organically

Disease resistance is important

Apple scab and canker are problematical

Seeds and plants

Seeds

From 1 January 2001 all seeds sown on organic units must themselves be certified as organic.

Until then, seed from non-organic sources may be used provided :

Organic seed of suitable varieties cannot be obtained from anywhere in the EU

and

It has not been treated with any pesticides

Plants

Already, vegetative propagation materials such as plant transplants, fruit bushes and trees, seed potatoes, onion setts, strawberry runners etc must be from a registered organic source.

Supplies are now increasing.

Marketing

There are many ways of marketing vegetables, and existing organic producers employ various methods to suit their scales of operations including :

Farm shops

Box delivery schemes

Supplying wholesalers

Supplying the general retail trade

Multiple retailer contracts

Supplying restaurants

Produce marketed through farm shops and box schemes is frequently supplemented by imported produce, particularly during the winter months.

Producer groups

The time and labour overheads associated with marketing and distribution are encouraging many vegetable producers to consider forming producer groups to :

Market and distribute jointly under a single 'brand name'

Produce jointly to planned agreements

Other horticultural produce

Vegetable producers have found that producing other types of organic horticultural produce supplements the vegetable production, including :

Herbs

Cut flowers

Bedding plants

Nursery stock and trees

Detailed husbandry information

For more information on growing organic vegetables a DANI booklet is available on request.

It is entitled 'Beginners' Guide to organic Vegetable Production' and is available from the contact shown below.

Contact for further information

Adrian Saunders
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Potato Origin and Spread

When the Spanish conquerors reached the Peruvian Andes in the early 1500s, they found the Incas growing potatoes. The Spaniards called them batata because they resembled the sweet potato grown in the West Indies. The English changed this to "potato."

No one knows who took the first potatoes to Europe. It seems certain that they had reached Spain by about 1570. Europeans did not know their food value. For a long time potatoes were grown only as an interesting plant. In 1613 they were shipped from England to Bermuda and from there to Virginia in 1621.

By the end of the 17th century potatoes had become the food staple of the Irish. A scientist, Antoine-Augustin Parmentier, dispelled the beliefs of French peasants that potatoes caused leprosy and fevers. Between 1773 and 1789 he wrote books and pamphlets urging potato cultivation. King Louis XVI popularized them by wearing potato flowers in his buttonhole. Frederick the Great of Prussia ordered his subjects to plant potatoes as food and cattle feed. By the end of the 18th century the potato was a major crop in continental Europe, particularly in Germany, and in the west of England.

The Irish economy became dependent upon the potato. Their cultivation continued to spread throughout the world during the first four decades of the 19th century. In 1845 and 1846 a disease called late blight, caused by the fungus Phytophthora infestans, virtually destroyed the Irish potato crops. The ensuing famine led to a more cautious attitude toward dependence on the potato. [24]

Considered by most botanists to be a native of the Peruvian-Bolivian Andes, the potato is one of the main food crops of the world. The edible part of a potato plant is the tuber, the swollen ends of its underground stems.

In the late 1980s the principal potato-producing countries were the Soviet Union, China, Poland, the United States, and Germany. The potato has long been a culinary delight. The most common ways of cooking potatoes are boiling, frying, and baking. Potatoes are frequently served whole, mashed as a cooked vegetable, or cut up as French fries. They are also made into potato chips, potato flour, potato starch, and alcoholic beverages. Potato starch has many industrial uses. It is used as a thickener in foods and provides tough resilient coatings for paper and textiles.

The Potato was introduced into Europe early in the sixteenth century, being brought to Spain from Peru, and was first brought into England in 1586 from North America, the colonists sent out by Sir Walter Raleigh bringing it back with them from Virginia.

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[24]Excerpted from *The Complete Reference Collection*.

Gerard, in his Herbal published in 1597, gives a figure of the Potato, under the name of 'Potato of Virginia' - to distinguish it from the Sweet Potato. The Herbal contains a portrait of himself on the frontispiece holding in his hand a spray of the Potato plant with flowers and berries.

Though Sir Walter Raleigh was the first to plant the Potato, on his estate at Youghall, near Cork, it is said that he knew so little about it that he tried to eat the berries, and on discovering their noxious character, ordered the plants to be rooted out. It is said that the gardener in doing so, first learnt the value of their wholesome tubers.

From Ireland, the Potato was soon after carried into Lancashire, but for some time Potatoes were only grown as a delicacy for the epicure, not as food for the people. Both Gerard and Parkinson refer to them in this manner. The Puritans opposed their cultivation, because no mention of them could be found in the Bible, and it was not until the middle of the eighteenth century that potatoes became common in this country as a vegetable. As late as 1716, Bradley, in his Historia Plantarum Succulentarum, speaks of them as 'inferior to skirrets and radishes.'

The Potato is indigenous in various parts of South America, plants in a wild state having been found on the Peruvian coast, as well as on the sterile mountains of Central Chile and Buenos Aires. The Spaniards are believed to have first brought it to Europe, from Quito, in the early part of the sixteenth century. It afterwards found its way into Italy, and from thence it was carried to Mons, in Belgium, by one of the attendants of the Pope's legate. In 1598 it was sent from Mons to the celebrated botanist Clusius at Vienna, who states that in a short time it spread rapidly throughout Germany.

In the time of James I, potatoes cost 2s. a pound, and are mentioned in 1619 among the articles provided for the royal household. In 1633, when their valuable properties had become more generally known, they were noticed by the Royal Society, and measures were taken to encourage their cultivation in case of famine; but it was not till nearly a century after this that they were grown to any extent in England. In 1725 they were introduced into Scotland and cultivated with much success, first in gardens, and afterwards (about 1760), when they had become plentiful, in the open fields.

On the Continent, the adoption of the Potato as a vegetable met with considerable prejudice, and it did not become a general article of food for some time after it was in general use here. Gerard says: 'Bauhine saith that he heard that the use of these roots was forbidden in Burgundy for that they were persuaded the too frequent use of them caused the leprosie' - a belief without any foundation, for the disease is now confined to countries where the Potato is not grown, and its antiscorbutic properties have been proved.

Linnaeus for some time objected to the use of the Potato on account of its connexion with the Deadly Nightshade and Bittersweet. Solanine, the poisonous active principle contained in the stalks, leaves and unripe fruit, is very powerful, and has not yet been fully investigated. It is also present in the peel of the tuber, but is dissipated and rendered inert when the whole potato is boiled and steamed, and is decomposed by baking.

The Potato is not only important as a valuable article of diet, but has many other uses, both medicinal and economic.

To carry a raw potato in the pocket was an old-fashioned remedy against rheumatism that modern research has proved to have a scientific basis. Ladies in former times had special bags or pockets made in their dresses in which to carry one or more small raw potatoes for the purpose of avoiding rheumatism if predisposed thereto. Successful experiments in the treatment of rheumatism and gout have in the last few years been made with preparations of raw potato juice. In cases of gout, rheumatism and lumbago the acute pain is much relieved by fomentations of the prepared juice followed by an application of liniment and ointment. Sprains and bruises have also been successfully treated by the Potato-juice preparations, and in cases of synovitis rapid absorption of the fluid has resulted. Although it is not claimed that the treatment in acute gout will cure the constitutional symptoms, local treatment by its means relieves the pain more quickly than other treatment.

Potato starch is much used for determining the diastatic value of malt extract.

Hot potato water has in years past been a popular remedy for some forms of rheumatism, fomentations to swollen and painful parts, as hot as can be borne, being applied from water in which 1 lb. of unpeeled potatoes, divided into quarters, has been boiled in 2 pints slowly boiled down to 1 pint Another potato remedy for rheumatism was made by cutting up the tubers, infusing them together with the fresh stalks and unripe berries for some hours in cold water, and applying in the form of a cold compress. The potatoes should not be peeled.

Uncooked potatoes, peeled and pounded in a mortar, and applied cold, have been found to make a very soothing plaster to parts that have been scalded or burnt.

The mealy flour of baked potato, mixed with sweet oil, is a very healing application for frost-bites. In Derbyshire, hot boiled potatoes are used for corns.

Boiled with weak sulphuric acid, potato starch is changed into glucose, or grape sugar, which by fermentation yields alcohol this spirit being often sold under the name of British Brandy.

A volatile oil - chemically termed Amylic alcohol, in Germany known as Fuselöl - is distilled by fermentation from potato spirit.

Although young potatoes contain no citric acid, the mature tubers yield enough even for commercial purposes, and ripe potato juice is an excellent cleaner of silks, cottons and woollens.

A fine flour is prepared from the Potato, and more used on the Continent than in this country for cake-making.

Garlic

The Common Garlic a member of the same group of plants as the Onion, is of such antiquity as a cultivated plant, that it is difficult with any certainty to trace the country of its origin. De Candolle, in his treatise on the Origin of Cultivated Plants, considered that it was apparently indigenous to the southwest of Siberia, whence it spread to southern Europe, where it has become naturalized, and is said to be found wild in Sicily. It is widely cultivated in the Latin countries bordering on the Mediterranean. Dumas has described the air of Provence as being 'particularly perfumed by the refined essence of this mystically attractive bulb.'

To prevent the plant running to leaf, Pliny (Natural History, XIX, 34) advised bending the stalk downward and covering it with earth, seeding, he observed, may be prevented by twisting the stalk.

In England, Garlic, apart from medicinal purposes, is seldom used except as a seasoning, but in the southern counties of Europe it is a common ingredient in dishes, and is largely consumed by the agricultural population. From the earliest times, indeed, Garlichas been used as an article of diet.

History Garlic was placed by the ancient Greeks (Theophrastus relates) on the piles of stones at cross-roads as a supper for Hecate, and according to Pliny garlic and onion were invocated as deities by the Egyptians at the taking of oaths.

It was largely consumed by the ancient Greeks and Romans, as we may read in Virgil's Eclogues. Horace, however, records his detestation of Garlic, the smell of which, even in his days (as much later in Shakespeare's time), was accounted a sign of vulgarity. He calls it 'more poisonous than hemlock,' and relates how he was made ill by eating it at the table of Maecenas. Among the ancient Greeks, persons who partook of it were not allowed to enter the temples of Cybele. Homer, however, tells us that it was to the virtues of the 'Yellow Garlic' that Ulysses owed his escape from being changed by Circe into a pig, like each of his companions.

Homer also makes Garlic part of the entertainment which Nestor served up to his guest Machaon.

There is a Mohammedan legend that:

'when Satan stepped out from the Garden of Eden after the fall of man, Garlick sprang up from the spot where he placed his left foot, and Onion from that where his right foot touched.'

There is a curious superstition in some parts of Europe, that if a morsel of the bulb be chewed by a man running a race it will prevent his competitors from getting ahead of him, and Hungarian jockeys will sometimes fasten a clove of Garlic to the bits of their horses in the belief that any other racers running close to those thus baited, will fall back the instant they smell the offensive odour.

Many of the old writers praise Garlic as a medicine, though others, including Gerard, are sceptical as to its powers. Pliny gives an exceedingly long list of complaints, in which it was considered beneficial, and Galen eulogizes it as the rustics' Theriac, or Heal-All. One of its older popular names in this country was 'Poor Man's Treacle,' meaning theriac, in which sense we find it in Chaucer and many old writers.

A writer in the twelfth century - Alexander Neckam - recommends it as a palliative for the heat of the sun in field labour, and in a book of travel, written by Mountstuart Elphinstone about 100 years ago, he says that-

'the people in places where the Simoon is frequent eat Garlic and rub their lips and noses with it when they go out in the heat of the summer to prevent their suffering from the Simoon.'

Garlic is mentioned in several Old English vocabularies of plants from the tenth to the fifteenth centuries, and is described by the herbalists of the sixteenth century from Turner (1548) onwards. It is stated to have been grown in England before the year 1540. In Cole's Art of Simpling we are told that cocks which have been fed on Garlic are 'most stout to fight, and 50 are Horses': and that if a garden is infested with moles, Garlic or leeks will make them 'leap out of the ground presently.'

The name is of Anglo-Saxon origin, being derived from gar (a spear) and lac (a plant), in reference to the shape of its leaves.

The use of Garlic as an antiseptic was in great demand during the past war. In 1916 the Government asked for tons of the bulbs, offering 1s. per lb. for as much as could be produced. Each pound generally represents about 20 bulbs, and 5 lb. divided up into cloves and planted, will yield about 38 lb. at the end of the growing season, so it will prove a remunerative crop.

The following appeared in the Morning Post of December 12, 1922:

'A Dog's Recovery

'Mr. W. H. Butlin, Tiptree, records the following experience: A fox-terrier, aged 14 years, appeared to be developing rapidly a pitiable condition, with a swollen neck and an ugly intractable sore at the root of the tail, and dull, coarse coat shedding abundantly. I administered "Yadil Antiseptic" in his drinking water and in less than a month the dog became perfectly sound and well, a mirabile dictu, his coat became firm, soft, and glossy.' (Yadil is a patent medicine said to contain Garlic.)

'In cases of arterial tension, MM. Chailley-Bert, Cooper, and Debrey, at the Society of Biology, recommended about 30 drops of alcoholic extract as a remedy. To be administered by the mouth or intravenously.'

Although only the cultivated Garlic is utilized medicinally, all of the other species have similar properties in a greater or less degree. Several of the species of Allium are natives of this country.

The CROW GARLIC (A. vineale) is widely distributed and fairly common in many districts, but the bulbs are very small and the labour of digging them would be great. It is frequent in pastures and communicates its rank taste to mike and butter, when eaten by cows.

NOTE.--Professor Henslow calls A. vineale the Field Garlic, and A. oleraceum the Crow Garlic.

RAMSONS (A. ursinum) grows in woods and has a very acrid taste and smell, but it also has very small bulbs, which would hardly render it of practical use.

Ransoms is also very generally known as 'Broad-leaved Garlic.'

The FIELD GARLIC (A. oleraceum) is rather a rare plant. Both this and the Crow Garlic have, however, occasionally been employed as potherbs or for flavouring. It is an old country notion that if crows eat Crow Garlic, itstupefies them.

Ramsons, the wild Wood Garlic, but for its evil smell would rank among the most beautiful of our British plants. Its broad leaves are very similar to those of the Lily-of-the-Valley, and its star-like flowers are a dazzling white, but its odour is too strong to admit of it being picked for its beauty, and many woods, especially in the Cotswold Hills, are spots to be avoided when it is in flower, being so closely carpeted with the plants that every step taken brings out the offensive odour.

There are many species of Allium grown in the garden, the flowers of some of which are even sweet-smelling (as A. odorum and A. fragrans), but they are the exceptions, and even these have the Garlic scent in their leaves and roots.

Medicinal Action and Uses Diaphoretic, diuretic, expectorant, stimulant. Many marvellous effects and healing powers have been ascribed to Garlic. It possesses stimulant and stomachic properties in addition to its other virtues.

As an antiseptic, its use has long been recognized. In the late war it was widely employed in the control of suppuration in wounds. The raw juice is expressed, diluted with water, and put on swabs of sterilized Sphagnum moss, which are applied to the wound. Where this treatment has been given, it has been proved that there have been no septic results, and the lives of thousands of men have been saved by its use.

It is sometimes externally applied in ointments and lotions, and as an antiseptic, to disperse hard swellings, also pounded and employed as a poultice for scrofulous sores. It is said to prevent anthrax in cattle, being largely used for the purpose.

In olden days, Garlic was employed as a specific for leprosy. It was also believed that it had most beneficial results in cases of smallpox, if cut small and applied to the soles of the feet in a linen cloth, renewed daily.

It formed the principal ingredient in the 'Four Thieves' Vinegar,' which was adapted so successfully at Marseilles for protection against the plague when it prevailed there in 1722. This originated, it is said, with four thieves who confessed, that whilst protected by the liberal use of aromatic vinegar during the plague, they plundered the dead bodies of its victims with complete security.

It is stated that during an outbreak of infectious fever in certain poor quarters of London, early last century, the French priests who constantly used Garlic in all their dishes, visited the worst cases with impunity, whilst the English clergy caught the infection, and in many instances fell victims to the disease.

Syrup of Garlic is an invaluable medicine for asthma, hoarseness, coughs, difficulty of breathing, and most other disorders of the lungs, being of particular virtue in chronic bronchitis, on account of its powers of promoting expectoration. It is made by pouring a quart of water, boiled hot, upon a pound of the fresh root, cut into slices, and allowed to stand in a closed vessel for twelve hours, sugar then being added to make it of the consistency of syrup. Vinegar and honey greatly improve this syrup as a medicine. A little caraway and sweet fennel seed bruised and boiled for a short time in the vinegar before it is added to the Garlic, will cover the pungent smell of the latter.

A remedy for asthma, that was formerly most popular, is a syrup of Garlic, made by boiling the bulbs till soft and adding an equal quantity of vinegar to the water in which they have been boiled, and then sugared and boiled down to a syrup. The syrup is then poured over the boiled bulbs, which have been allowed to dry meanwhile, and kept in a jar. Each morning a bulb or two is to be taken, with a spoonful of the syrup.

Syrup made by melting 1 1/2 OZ. of lump sugar in 1 OZ. of the raw expressed juice may be given to children in cases of coughs without inflammation.

The successful treatment of tubercular consumption by Garlic has been recorded, the freshly expressed juice, diluted with equal quantities of water, or dilute spirit of wine, being inhaled antiseptically.

Bruised and mixed with lard, it has been proved to relieve whooping-cough if rubbed on the chest and between the shoulder-blades.

An infusion of the bruised bulbs, given before and after every meal, has been considered of good effect in epilepsy.

A clove or two of Garlic, pounded with honey and taken two or three nights successively, is good in rheumatism.

Garlic has also been employed with advantage in dropsy, removing the water which may already have collected and preventing its future accumulation. It is stated that some dropsies have been cured by it alone.

If sniffed into the nostrils, it will revive a hysterical sufferer. Amongst physiological results, it is reported that Garlic makes the eye retina more sensitive and less able to bear strong light.

The juice of Garlic, and milk of Garlic made by boiling the bruised bulbs in milk is used as a vermifuge.

---Preparations---Juice, 10 to 30 drops. Syrup, 1 drachm. Tincture, 1/2 to 1 drachm.

Wine of Garlic - made by macerating three or four bulbs in a quart of proof spirit is a good stimulant lotion for baldness of the head.

Used in cookery it is a great aid to digestion, and keeps the coats of the stomach healthy. For this reason, essential oil is made from it and is used in the form of pills.

If a very small piece is chopped fine and put into chicken's food daily, it is a sure preventative of the gapes. Pullets will lay finer eggs by having garlic in their food before they start laying, but when they commence to lay it must be stopped, otherwise it will flavour the eggs.

Mrs. Beeton (in an old edition of her Household Management, 1866) gives the following recipe for making 'Bengal MangoChutney,' which she states was given by a native to an English lady who had long been a resident in India, and who since her return to England had become quite celebrated amongst her friends for the excellence of this Eastern relish.

Ingredients. 1 1/2 lb. moist sugar, 3/4 lb. salt, 1/4 lb. Garlic, 1/4 lb. onions, 3/4 lb. powdered ginger, 1/4 lb. dried chillies, 3/4 lb. dried mustard-seed, 3/4 lb. stoned raisins, 2 bottles of best vinegar, 30 large, unripe, sour apples.

Mode. The sugar must be made into syrup; the Garlic, onions and ginger be finely pounded in a mortar; the mustard-seed be washed in cold vinegar and dried in the sun; the apples be peeled, cored and sliced, and boiled in a bottle and a half of the vinegar. When all this is done, and the apples are quite cold, put them into a large pan and gradually mix the whole of the rest of the ingredients, including the remaining half-bottle of vinegar. It must be well stirred until the whole is thoroughly blended, and then put into bottles for use. Tie a piece of wet bladder over the mouths of the bottles, after which they are well corked. This chutney is very superior to any which can be bought, and one trial will prove it to be delicious.

Carrot

History The Carrot was well known to the ancients, and is mentioned by Greek and Latin writers under various names, being, however, not always distinguished from the Parsnip and Skirret, closely allied to it. The Greeks - Professor Henslow tells us - had three words: Sisaron, first occurring in the writings of Epicharmus, a comic poet (500 B.C.); Staphylinos, used by Hippocrates (430 B.C.) and Elaphoboscum, used by Dioscorides (first century A.D.), whose description of the plant applies accurately to the modern Carrot. Pliny says:

'There is one kind of wild pastinaca which grows spontaneously; by the Greeks it is known as staphylinos. Another kind is grown either from the root transplanted or else from seed, the ground being dug to a very considerable depth for the purpose. It begins to be fit for eating at the end of the year, but it is still better at the end of two; even then, however, it preserves its strong pungent flavour, which it is found impossible to get rid of.'

In speaking of the medical virtue of the first species (which is evidently the Carrot, the second variety presumably the Parsnip), he adds, 'the cultivated has the same as the wild kind, though the latter is more powerful, especially when growing in stony places.'

The name Carota for the garden Carrot is found first in the writings of Athenaeus (A.D. 200), and in a book on cookery by Apicius Czclius (A.D. 230). It was Galen (second century A.D.) who added the name Daucus to distinguish the Carrot from the Parsnip, calling it D. pastinaca, and Daucus came to be the official name in the sixteenth century, and was adopted by Linnaeus in the eighteenth century.

From the time of Dioscorides and Pliny to the present day, the Carrot has been in constant use by all nations. It was long cultivated on the Continent before it became known in this country, where it was first generally cultivated in the reign of Queen Elizabeth, being introduced by the Flemings, who took refuge here from the persecutions of Philip II of Spain, and who, finding the soil about Sandwich peculiarly favourable for it, grew it there largely. As vegetables were at that time rather scarce in England, the Carrot was warmly welcomed and became a general favourite, its cultivation spreading over the country. It is mentioned appreciatively by Shakespeare in The Merry Wives of Windsor. In the reign of James I, it became the fashion for ladies to use its feathery leaves in their head-dresses. A very charming, fern-like decoration may be obtained if the thick end of a large carrot be cut off and placed in a saucer of water in a warm place, when the young and delicate leaves soon begin to sprout and form a pretty tuft of verdant green, well worth the slight trouble entailed.

Its root is small and spindle-shaped whitish, slender and hard, with a strong aromatic smell and an acrid, disagreeable taste, very different to the reddish, thick, fleshy, cultivated form, with its pleasant odour and peculiar, sweet, mucilaginous flavour. It penetrates some distance into the ground, having only a few lateral rootlets.

<u>Parts Used Medicinally</u> The whole herb, collected in July; the seeds and root. The whole herb is the part now more generally in use.

<u>Medicinal Action and Uses</u> Diuretic, Stimulant, Deobstruent. An infusion of the whole herb is considered an active and valuable remedy in the treatment of dropsy, chronic kidney diseases and affections of the bladder. The infusion of tea, made from one ounce of the herb in a pint of boiling water, is taken in wineglassful doses. Carrot tea, taken night and morning, and brewed in this manner from the whole plant, is considered excellent for lithic acid or gouty disposition. A strong decoction is very useful in gravel and stone, and is good against flatulence. A fluid extract is also prepared, the dose being from 1/2 to 1 drachm.

The seeds are carminative, stimulant and very useful in flatulence, windy colic, hiccough, dysentery, chronic coughs, etc. The dose of the seeds, bruised, is from one-third to one teaspoonful, repeated as necessary. They were at one time considered a valuable remedy for calculus complaints. They are excellent in obstructions of the viscera, in jaundice (for which they were formerly considered a specific), and in the beginnings of dropsies, and are also of service as an emmenagogue. They have a slight aromatic smell and a warm, pungent taste. They communicate an agreeable flavour to malt liquor, if infused in it while in the vat, and render it a useful drink in scorbutic disorders.

Old writers tell us that a poultice made of the roots has been found to mitigate the pain of cancerous ulcers, and that the leaves, applied with honey, cleanse running sores and ulcers. An infusion of the root was also used as an aperient.

<u>Medicinal and General Uses</u>   The chief virtues of the Carrot lie in the strong antiseptic qualities they possess, which prevent all putrescent changes within the body.

Carrots were formerly of some medicinal repute as a laxative, vermifuge, poultice, etc., and the seeds have been employed as a substitute for caraways.

At Vichy, where derangements of the liver are specially treated, Carrots in one form or the other are served at every meal whether in soup or as vegetables, and considerable efficacy of cure is attributed to them.

In country districts, raw Carrots are still sometimes given to children for expelling worms, and the boiled roots, mashed to a pulp, are sometimes used as a cataplasm for application to ulcers and cancerous sores.

Carrot sugar, got from the inspissated juice of the roots, may be used at table, and is good for the coughs of consumptive children.

A good British wine may be brewed from the root of the Carrot, and a very tolerable bread prepared from the roots, dried and powdered. The pectic acid contained can be extracted from the root and solidifies into a wholesome, appetizing jelly.

In Germany, a substitute and adulteration for coffee has been made of Carrots chopped into small pieces, partially carbonized by roasting and then ground.

In France and Germany a spirit is distilled from the Carrot, which yields more spirit than the potato. The refuse after making the spirit is good for feeding pigs.

Attempts have also been made to extract sugar from Carrots, but the resulting thick syrup refuses to crystallize, and in competition with either cane sugar or that obtained from the beetroot, it has not proved commercially successful.

Carrots are also used in winter and spring in the dairy, to give colour and flavour to butter, and a dye similar to woad has been obtained from the leaves.

Recipes

---Carrot Jam---
Wash and grate some carrots; boil until reduced to a thick pulp. To 1 Ib. of this pulp add 9 oz. sugar, the juice and grated rind of 2 lemons, and 3 oz. margarine. Boil the mixture well for 45 minutes to 1 hour. The result is a useful and inexpensive jam, which can be made for 6d. to 8d. a lb. (according to the price of the lemons), if all materials have to be bought, and for considerably less by those who have home-grown carrots available.

---Preserved Young Carrots---
Turn the carrots in their own shape, and as you do so, them turn into hot water; when all are ready, put them in a stewpan with water enough to cover them; add fresh butter in the proportion of an ounce to the pound of carrots, and salt to season; boil the carrots in this till half done, and then arrange them neatly in tin boxes; fill up with their own liquor, solder down, boil for hour, and put them away in the cool.

BEE. People have known ever since ancient times that the insects called bees make delicious honey from the nectar of flowers. There are more than 20,000 species of bees, and they are found all over the world except in Antarctica. Most people throughout the world recognize honeybees, and people in temperate regions know bumblebees as well (in some places they are called humble-bees). In Central America and South America many persons are familiar with tropical stingless bees.

Physical Characteristics

Bees are flying insects that are related to wasps, hornets, and ants. Most bees have short, thick bodies covered with hair and, like all insects, six legs and three body parts: head, thorax, and abdomen. The thorax in turn has three segments, each with a pair of legs. A tiny waist connects the thorax and abdomen. (*See also* Ant; Wasp.)

Ordinarily, most bees fly about 12 1/2 miles (20 kilometers) per hour, but they can fly much faster. They have two pairs of wings. One pair is attached to each of the last two segments of the thorax, but front and back wings are joined so that they may look like only one. The rapid movements of the wings make a humming sound in flight.

With three single eyes on top of their heads and two huge, helmet-like compound eyes, bees can see color, pattern, and movement. The many facets of their compound eyes give them a total image in a mosaic of dots. Bees see all colors humans do except red, and they see ultraviolet, which humans cannot. Ultraviolet is often reflected by red flowers. Bees can also detect the polarization of light, which humans cannot. For example, in a blue sky polarized light forms a distinctive pattern around the sun, and even when the sun is behind the clouds bees can perceive that pattern and orient themselves to it.

On the lower part of their heads bees have biting jaws (mandibles) and a mouth-tongue proboscis, of several parts, which they use for sucking and lapping. Bees can distinguish very slight differences in sweet and bitter tastes, and they can also identify sour and salty tastes. Their front legs and feelers (antennae), as well as their proboscises are used for tasting. The antennae are primarily for sensing fragrances: bees find the perfumes of flowers even more enticing than their colors and shapes. Bees have no ears, but they can sense the vibrations of the surfaces upon which they alight.

The largest bees, which include some of the leafcutter and carpenter varieties, may be up to about 1 1/2 inches (4 centimeters) long. Bumblebees are larger than most--about 1 inch (2.5 centimeters) long. Honeybees range from about 1/2 inch to 1 inch (1.3 to 2.5 centimeters) long, depending upon the species. Some of the small leafcutter bees are only 2/5 inch (1 centimeter) long, and sweat bees are 3/10 inch (0.7 centimeter) long. The tiniest species, the mosquito bees, may be only 3/50 inch (0.2 centimeter) long.

Most bees have black bodies, many with yellow or brown markings. Others have yellow, red, brown, and metallic green or blue bodies, some with brilliant metallic red or purple markings. Honeybees are dark brown with dark yellow stripes. Bumblebees are usually black with wide yellow or orange bands.

Food from Flowers

Depending upon its size and the length of its proboscis, a bee can enter many kinds of blossoms to sip nectar, the sweet liquid secreted by the flower's glands. The bumblebee has a long proboscis and so is better equipped than many others for taking nectar from red clover, the flowers of which are made up of clusters of tubular blossoms. The nectar is carried in a special part of the bee's stomach. During the digestive process enzymes are added, and the nectar becomes honey. Later it is regurgitated into the cells of the comb within the hive. When full, the cells are left until the honey has dried and thickened to the right consistency. Then the bees cap the cells with wax to preserve the honey and prevent further drying.

Pollen gathered from flowers clings to special branched or feathered hairs on the bee's body. After pollen has accumulated, the bee brushes it off and molds it into tiny balls mixed with honey from its mouth. This is beebread, the food of the young bees. The bee pushes these pellets into a particular formation of hairs or bristles for carrying them back to the nest. Honeybees have a pollen basket of stiff hairs on their hind legs. Leafcutting bees have a dense brush on the underside of the abdomen.

Pollination

Fascinated by both color and shape, bees show a strong preference for flowers with elaborate embellishments and respond eagerly to patterns of color, particularly of yellow, blue, and ultraviolet. A more deeply shaded pattern is present near the center of some blossoms. This clearly marked area acts as a carpet of color to guide the bee to the nectar.

The liplike petals of many flowers provide a place where a bee can land before entering. When a bumblebee alights on the lip of a snapdragon, the bumblebee's weight, which is greater than that of most bees, opens the flower's mouth, letting the bee enter the inner chamber to sip the nectar.

As bees go from one blossom to another, much of the pollen that clings to their bodies is transferred to the flowers of other plants of the same species, pollinating, or fertilizing, them. This permits the plants to produce their fruits and seeds. The bees' greatest value by far is as pollinators of plants.

The Sting and Other Defenses

A female bee has an egg-laying device (ovipositor) located at the end of its abdomen; the ovipositor also serves as a weapon and can inflict a painful sting. The bee's sting has no food-capturing function. It has come to be used for defense against animals and humans that raid their honeycombs, and against robber bees and parasitic bees attempting to enter their nests.

Most bees can sting many times, but a honeybee worker has a tiny, hook-shaped barb that is caught inside the victim. This bee cannot fly away without tearing out its ovipositor and some internal organs--a fatal injury. After the dying bee has flown away, its poison sac and the muscles left attached to the ovipositor keep pumping poison into the victim. As soon as possible the sting should be removed without squeezing the poison sac.

Africanized honeybees, also called killer bees, are particularly aggressive. They are descended from African bees that were imported into Brazil in 1956. The imported bees escaped in 1957 and began to mate with European honeybees--the kind found in most hives. Although the sting of one Africanized bee is no more dangerous than that of a European honeybee, the Africanized bees release a chemical when they attack that signals other bees to come and join the attack. These bees may swarm over great distances in pursuit of a raider of their hives, and they have been known to attack in such numbers as to kill farm animals and humans. Since 1957 they have been moving steadily northward, and the first swarm entered the United States in October 1990.

Bumblebees sting when their nest is disturbed, but they are not easily aroused when they are gathering nectar. Sweat bees, attracted by perspiration, may alight on a person's skin in summer. Their stings are sharp but not as painful as those of the honeybee.

Tropical stingless bees defend their colony by crawling into the eyes, ears, and nose of an animal or under the clothing of a human raider. They bite, and create unpleasant sensations because of their sheer numbers. Some species secrete a caustic chemical that burns the skin.

Nesting and Life Cycle

Bees vary greatly in nesting practices, depending upon the species. They may be classified as social bees, solitary bees, and parasitic bees (also called guest bees or cuckoo bees).

Social bees are members of colonies in which they cooperate with others to build the nest and to feed and protect the young. Colonies may contain as few as ten or as many as 80,000 bees. There are two kinds of females among the social bees, and they look quite different. The sexually mature, fertile females, called queens, are long and slender; the sexually undeveloped females, called workers, are small and chunky. The workers become their mother-queen's helpers as housekeepers, nurses of the young, builders, guards to keep intruders from the nest, and foragers for food.

Only about 500 species of the more than 20,000 species of bees are social. They include honeybees, bumblebees, and tropical stingless bees.

Solitary bees care only for themselves and their immediate brood. Each female makes her own nest and cares for her offspring. The vast majority of bees are solitary, including leafcutter bees, mining bees, and carpenter bees.

Parasitic bees, or guest bees, have no body parts for collecting pollen and do not feed or care for their offspring. They sneak into the nests of related species of bees to lay their eggs. The larvae that develop from these eggs are not welcome guests, because they often have huge jaws and use them to kill the larvae of their hosts. Parasitic bees are sometimes called cuckoo bees because, like the European cuckoo, which is a bird, they lay their eggs in the nests of others. Many species of sweat bees are parasitic.

During its life each bee undergoes a complete metamorphosis in four stages: egg, larva, pupa, and adult. The average bee egg is a tiny white sausage-shaped object about 14/100 inch (3.5 millimeters) long. From it hatches the larva, a white wormlike grub with no eyes and no legs. After spending two or three weeks eating in its cell, the grub becomes less active as it enters the pupal stage. In some species the grub first spins a cocoon around itself before becoming a pupa. While outwardly still, inwardly the pupa is transforming into the adult bee.

The sex of the bee in most species is determined by whether or not the egg is fertilized. Fertilized eggs develop into females, unfertilized ones into males. Male bees are called drones. They do no work and exist only for the possibility of mating with the females.

Honeybees

For at least 4,000 years honeybees have been kept for their honey and for beeswax, a tallow-like substance used to make candles, polishes, ointments, and many other products. Of great economic importance in most parts of the world, honeybees are native to Europe, western Asia, and Africa. They are also widespread in North America, where they were brought by the early white settlers.

The honeybees have a definite caste system; they are divided into three groups within the hive--the queen, the workers, and the drones. The task of the queen is to lay eggs. The drones are males that can mate with the queen. The workers are female bees that do not lay eggs but do all the work necessary for the upkeep and protection of the hive.

Although beekeeping (also called apiculture) has been practiced for many centuries, bees are not truly domesticated in the sense of being tamed. Those living in man-made hives behave no differently from those living in nests they make themselves.

In the wild, worker bees seek out a sheltered place such as a hollow tree or log, a cave, or a crevice in a rock or a building. Or they may choose to hang their nest from a tree branch. Using wax secreted between scalelike plates on the underside of their abdomens, they build clusters of cells called combs. In the wild, combs may be somewhat rough and irregular, but each cell of the comb is a precisely shaped, six-sided tube open on one end. Two blocks of cells are placed back to back, forming a two-sided, or double-edged, comb. The comb hangs vertically with the open ends of the cells facing out the sides. To keep the larvae, which develop within, from falling out, cells are constructed with a slight upward tilt.

Beekeepers provide their colonies of bees with wooden boxes that are called hives. Inside the hives the beekeepers hang sheets of wax in wooden frames for the bees to use as foundations in building their combs. Ten or twelve of these frames can be hung side by side in each hive box.

As is the case in all colonies of social bees, the only sexually mature female honeybee is the queen. When she flies away from the nest to mate, she gives off an odor (a pheromone) that the drones find irresistible, and they follow her. The streamlined queen flies faster and higher than the majority of the short, stocky drones. As she soars upward, many of them give up the pursuit. From the few drones that can follow her as she continues on a rising, whirling flight, she chooses one to couple with. After mere seconds her mate falls dying to the ground, and she chooses another. Several drones in succession may meet the same fate before the queen returns to the nest alone. She never leaves the nest again, unless she moves with a swarm of worker bees to a new home. Fertile until shortly before she dies, she lays up to 2,000 eggs per day, one to a cell. The cells in which future workers and drones develop are similar and ordinary. But for the egg and larvae that will develop into a new queen, the cell must be enlarged. It usually resembles a peanut shell hanging from the comb.

Three days after it is laid, an egg hatches into a tiny larva. At first all larvae are fed royal jelly, or beemilk, a thick whitish nutritional substance that young worker bees regurgitate into the cells from a pair of glands. But only the future queens are kept on this diet. Future workers and drones are switched to beebread, made from pollen.

In about six days a larva grows to the size of an adult bee, filling its cell. Then a worker caps the cell with wax, and the larva inside spins a silk cocoon and becomes a pupa. In about 12 days the process of changing into a winged adult is at last completed, and the new bee emerges.

Newly emerged workers usually stay in the nest or hive for a time, first helping to clean out used cells, and then, when their glands begin producing royal jelly, feeding the larvae. At 10 to 16 days old the workers can secrete wax, which is softened by chewing and used to repair and construct cells.

Once the young worker's wax glands stop producing, its job is to receive the nectar and pollen brought into the nest by older workers and to store it in the cells. By the age of 20 days the young worker may become a guard at the entrance to the nest. Eventually it leaves the nest to begin its lifelong career of foraging for nectar, pollen, water, or propolis. Propolis, also called bee glue, is a sticky resin from the buds of trees; it is used to repair cracks in the nest or hive and to cover the bodies of such intruders as moths, mice, or lizards that have been stung to death.

The division of work assignments in a hive is not rigid. Older bees may spend time at the nest or in the hive, eating and resting. They can reactivate their appropriate glands if young bees are few and the needs of the hive require more workers inside. A worker may live several months, but when there are empty cells and much nectar to be gathered she may work very hard and die in only six weeks.

Clustering and swarming. In the autumn the workers usually drive the drones away to starve or freeze. When winter arrives in cooler regions, all members of the honeybee colonies that nest in the open will die. But hive bees and those that nest in a sheltered spot can live through the cold weather by clustering. The bees of the colony huddle close together and form a ball around one of the combs. By moving their legs, wings, and bodies, the bees on the inside of the ball manage to keep warm, protected by the bees on the outside. And when the bees on the outside become cold, they change places with some of the bees on the inside. In extremely cold weather temperatures inside a cluster may be as much as 100o F (55o C) higher than outdoors. The cluster moves slowly as a unit over the combs so that the bees can eat the honey they have stored. Once midwinter is passed, the queen begins laying her eggs inside the cluster, starting a fresh colony.

When an old nest becomes crowded or a new queen emerges, honeybees may start a new colony by swarming. The old queen leaves the nest with a swarm of half the workers. Forming a dense throng around the queen, the swarm may hover in a tree while a few scouting workers seek out a suitable location for their new nest. If no new queen has emerged at the old nest, the workers remaining there rear larvae to be new queens, and the first one to emerge as an adult kills the others in their cells with her sting. The new queen quickly mates and begins laying eggs in 12 days.

Dance of the honeybees. A worker honeybee lets the other workers know about a new source of food it has discovered by rapidly vibrating its wings and performing a dance. When it returns to the nest, it first gives the others a sample of the nectar. From this, and from the scent on its body, they learn what kind of food the worker has found. That bee then performs a dance on the surface of the comb to show the others how far and in what direction to go to find the new food source.

The speed of the dance and its length can communicate the relative ease or difficulty of the flight: uphill or against the wind takes more energy. If the amount of food to be found there is great, the dance lasts longer and is more enthusiastic. Therefore, it arouses a greater number of bees. The number persuaded to go there will be proportionate to the amount of food to be found.

Bumblebees

Bumblebees are found throughout much of the world, primarily in the temperate and northern regions. In the spring a young bumblebee queen seeks a place suitable for building her nest. It may be a hole in the ground, a small pile of grass or debris, or the abandoned nest of a bird, mouse, ant, or termite. Using wax secreted from her abdomen, she makes a honeypot and fills it with nectar from flowers. Then she makes a cell, lays a few eggs in it, seals it, and sits on it like a brooding hen.

In three to five days her eggs hatch into four to eight grublike larvae. She may open their cell to feed them from the honeypot, or in some species the larvae eat through an opening from their cell into the honeypot. They eat and grow for about a week, and then each larva spins a silk cocoon and becomes a pupa. In two more weeks newly formed bees, pale, weak, and wet, crawl out to feed at the honeypot. In a few days they are bright and fluffy and can help care for the new larvae that their mother has been tending in newly built cells. Later they begin to forage for food, leaving the queen free to concentrate on laying eggs and adding more cells to form a rough comb. She uses the empty cocoons in her construction, strengthening them with wax. In hot summer weather bumblebee workers fan with their wings to cool the brood, and their buzzing can be heard at a distance.

In late summer, after the queen has raised many workers to feed the young and to forage, new young queens and drones are also raised. Some males develop from unfertilized eggs laid by the queen, but most hatch from eggs laid by workers. The drones seek out the new queens and mate with them on the ground or in the air near it.

In the fall the old queen stops laying eggs, and when the weather turns cold, she dies along with all her workers and drones. The mated young queens leave the nest to find a sheltered place to hibernate, usually in the ground. When spring comes, they will emerge to seek suitable places for building their nests. Thus the cycle is repeated.

Tropical Stingless Bees

Commonly kept for their honey, tropical stingless bees are widespread throughout Mexico and in Central and South America. A few are found in tropical Africa, Asia, and Australia.

Beekeepers provide these bees with sections of hollow log for their nests and they plug the ends of the log with clay. To obtain the honey a plug is removed, and the whole nest may be taken out, crushed, and the honey strained.

Worker bees construct the combs of cerumen, a mixture of wax and plant resin. Most species of tropical stingless bees build inner walls of thin, paper-like cerumen that contain a number of tiny holes as passageways inside the nest. Some species construct long entrance halls. Remodeling of the nests goes on continually. Used cells are rebuilt; walls are moved; and the locations of entrances are changed so that additions can be made to the comb. Unlike the honeybees, who hang their combs vertically with the cells opening on the sides, the tropical stingless bees arrange their combs horizontally with the cells opening at the top. Some combs resemble a spiral staircase, while others are irregular clusters of many-sided cells.

Tropical stingless bees form social units that are in many ways as complex as those of honeybees. Some species have a dance similar to that of the honeybees, providing directions for flying to a source of food. Other species, during their return trip to the nest from a good food source, will light repeatedly and rub scent from glands on their jaws, marking an aromatic trail the other bees can track back to the source.

Solitary Bees

Most bees are solitary. They have no caste system and do not cooperate with others in building nests and providing for the young. Each female can mate and lay eggs, and each makes her own nest of cells. However, they often live as close neighbors to others like themselves, and they sometimes share the same hole in the ground as an entrance to separate nests.

After mating, the female bee makes a small nest, usually in the ground, often digging her tiny entranceway either vertically or horizontally into a bank of soil. Inside the nest she digs a cell, or makes one of wax, wood, or other material, and lays an egg in it. She then gathers pollen, puts it in the cell with the egg, and closes the cell. When the egg hatches, she will be gone, but her larva will be provided for. The female bee may make several more cells and stock them in the same way. She then seals them before she leaves the nest to die. Both female and male larvae eat their provisions and become pupae. They emerge as adults, fly away, and seek mates. The young mated females in turn will make their own nests.

Leafcutter bees are found throughout the world. The female bee searches for a convenient, ready-made space in such places as a hollow stem, rotten wood, or the ground. There she shapes her nest in the form of a long tunnel. She constructs a cell, using circles she cuts from the leaves of shrubs such as roses or other plants. She begins by cutting a circle for the end of the cell. Next she cuts a series of oval pieces for the side walls. When the cell is made, she stores a mixture of pollen and honey inside, lays an egg, and finally closes the cell with a perfectly fitted disk of cut leaf. Then she begins the sequence again, constructing another cell in the same way, and continues her activities until the nest is filled.

Mining bees tunnel into soil or clay banks. The bee begins her nest with a long corridor, which she lines with clay moistened with regurgitated water. Short hallways lead off the main corridor to the nursery cells. The bee then fills the cells with nectar for her future young and lays an egg on top.

Carpenter bees bore into plant stems or even into solid wood buildings, fences, or posts. They then make their nests in the tunnel.

Classification

The more than 20,000 species of bees belong to a superfamily called Apoidea, of the order Hymenoptera, which includes ants, wasps, and hornets. They are one of the large class of Insecta of the phylum Arthropoda (invertebrate animals with jointed legs and segmented bodies).

There are three important and large families of bees. The Apidae, small to large bees found throughout the world, includes all social bees (honeybees, bumblebees, and tropical stingless bees), carpenter bees, and some mining bees. Most honeybees native to Europe, Africa, and the Middle East have the genus and species name, or scientific name, *Apis mellifera.* Most honeybees native to India, Indochina, and Japan are *Apis cerana.* Bumblebees are of the genus *Bombus*, which has about 200 different species. The Megachilidae family, medium to large bees found throughout the world, includes more than 1,000 species of leafcutter bees, some sweat bees, and some parasitic bees. The Halictidae family, small bees found throughout the world, includes some of the sweat bees. [25]

Medicinal Plants with a Potential Niche Market for Propagators

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The American public has a longtime love affair going with herbs! A few years ago everyone was grinding basil for pesto, stuffing rosemary in their vinegar bottles, and putting French tarragon sprigs on their chicken. Then they moved into herbal wreathes, soaps, and potpourris. Now companies across the nation indicate that herbal medicines and aromatherapy are the fastest growing sales categories. The general feeling in the industry is that the public's interest in herbs has not reached its peak and healthy growth is expected in the future.

So what can that mean for you as a propagator? Retail nurseries report that gardeners are very interested in growing their own medicinal herb plants. People are in the market for shade loving perennials, such as ginseng and goldenseal; sun-loving plants, such as purple coneflower;and shrubs and trees, such as witch hazel and ginkgo.

The companies producing medicinal herb products, such as the capsules and tinctures you find in health food stores and pharmacies, have traditionally purchased most of their raw herbs from India, China, and the Eastern European countries. As the medicinal herb industry has matured, however, the companies buying these herbs have instituted new quality control efforts that include testing for active compounds, purity, and bacterial contamination. Many companies have found that foreign imports do not meet their new high standards.

This has opened up a market for American growers to produce large acreages of medicinal herbs. This, in turn, has created a market for the seeds and plants to produce these herbs. That is where you as a propagator can get involved with herbs. So let me tell you about some of the plants that are currently in demand and some of what is known about producing these plants.

[25]Excerpted from *The Complete Reference Collection*.

There are several important points to keep in mind before you jump into medicinal plant production. One is that you are working with "new crops". Thus, your county extension office will not have information packed bulletins on how to grow most of these plants. I encourage you to read everything you can about the herb plants we DO know something about and about plants that are similar to what you want to grow. Talk to the people at your local botanical garden and to herb enthusiasts. Mostly, you must rely on your own experience, horticultural knowledge, and "gut instincts". Keep careful notes on everything you do and the results you obtain. You could quickly find yourself the expert on propagation of one of these little known medicinal herbs.

Second, be very careful about where you buy your seeds and planting stock. This is a new industry and quality standards aren't always what they should be. Check your sources out very carefully. If you decide to collect seeds and planting stock from wild populations, be certain to check on local regulations and the status of plants before you head out. Some of the more popular medicinal herbs are endangered or protected species in some states..

For any of the shade-loving plants, of course, you must provide shade. Commercial herb growers use natural shade or artificial shade provided by wood lath or polypropylene shade cloth. When using artificial shade, I recommend tall structures, about 8-9 feet tall, with two open ends for good ventilation.

What are some of the plants in demand? Right now, one of the plants in greatest demand is goldenseal, *Hydrastis canadensis*, a shade loving, herbaceous perennial. It is used for many purposes including as a treatment for AIDS, cancer, various digestive disorders, and to boost the immune system. It is native to North America and used to grow in abundance throughout the Appalachian region. Unfortunately, native populations have been seriously reduced by over collection and it is now an endangered species in North Carolina and under new regulations for international trade.

Goldenseal has a rhizome by which it spreads rapidly and is easily propagated. In fall or spring, these rhizomes can be cut into pieces. Try to include an obvious bud on each piece, but research indicates that it is even more important to have good roots. Goldenseal produces a raspberry like fruit, which is full of seeds. These seed require special handling, such as they cannot be allowed to dry out. Most growers find they get the best germination when the seed are sown immediately after they are extracted from the fruit. This, of course, is not real practical for the propagator.

Studies are underway at North Carolina State University looking at seed extraction methods, seed disinfection treatments, seed storage temperature regimes, and planting dates. So far, the best germination has been obtained from seed that had been held at 70 degrees F prior to sowing in late August or late October.

Studies are also being conducted on soil fertility, mulch, and spacing for goldenseal. For the fertility studies, goldenseal was grown for three years in forest soil amended to provide four levels of lime, phosphorus, and nitrogen. Emergence the first year was greatly influenced by lime application. Emergence was very low where the soil pH was lower than 4.8 or higher than 6.7. If the plants made it through that first year at the extreme pH levels, they exhibited 90% or better germination the following years. Any supplemental nitrogen reduced emergence that first year, but had little effect in the following years. The response to phosphatorus, supplied as superphosphate, was much the same. As with emergence, the plants were tallest around pH 5.5 and 6.5.

Goldenseal roots and rhizomes are the plant parts of interest to the propagators and the botanical ingredient companies. There was a dramatic response in growth of these parts to soil pH. The bottom line is, remember to keep pH around 5.5 to 6.5. These numbers will be refined as further research is conducted. Fresh root weight was inversely related to increasing nitrogen rate during the first year of growth. There were no significant responses to nitrogen rate after the second or third year, however. The response to phosphate additions was very similar.

Studies are now underway looking at spacing effects. Plants emerged first in the closest spacings of 2x2 inches and 4x4 inches. Mulch studies were also initiated in 1997. Plants grew best the first season with bark mulches, pine needles, and sawdust. Straw mulch resulted in poor growth and severe slug damage. Shade requirements are also being examined with plants growing under polypropylene shade providing 30%, 47%, 63%, 80% shade and wood lath.

So, as you can see--there was a lot we didn't know, and still don't know, about growing goldenseal. However, for those willing to try and work out the cultivation methods, there are good markets for goldenseal seedlings and mature plants for planting stock. There also is a limited, but growing market, for goldenseal plants for retail sales.

American ginseng (*Panax quinquefolium*) is another medicinal herb that has a long history of cultivation in North America. You will have no problem finding information on ginseng seed handling and plant growing. Ginseng seed requires very special handling and a stratification period of about 18 months. Like goldenseal, ginseng seed must never be allowed to dry out. There are a large number of suppliers of ginseng seed and roots for commercial growers. However, there are few nurseries catering to the home gardeners. A few enterprising growers have tapped into this lucrative hobbyist market. These plants sell for $12 to $25 a piece.

Other shade requiring medicinal plants in demand include black cohosh (*Cimicufuga racemosa*)--a perennial shrub, fairly easy to propagate by root division or seed. The roots of this plant are used to treat various feminine disorders. Mayapple (*Podophyllum peltatum*) is another woodland plant in demand because of its cancer fighting properties. It is propagated primarily by dividing the roots in the spring because the seeds can be hard to germinate. The plant thrives, however, under cultivation. Bloodroot (*Sanguinaria canadensis*) has a pretty early spring flower which makes this plant especially attractive to the retail market. Bloodroot can be easily propagated by seed or root division. Bloodroot is used in a popular toothpaste because of its antiplaque properties. It also has other antibacterial properties. It can be quite toxic, however, at low doses!

Chamelirium luteum goes by many common names, including fairy wand, star grub root, Helonias, and devil's bit. The plant is an erect, fleshy, perennial with a rosette of leaves at the base. Male and female flowers are borne on separate plants. This plant has not really been cultivated and we know little about its requirements. However, demand for this plant is increasing. The roots are used to treat a variety of feminine disorders. Any herb that can be of use to the aging baby boomers, especially to help them deal with problems related to menopause, prostate, poor memory, and low energy, will have a strong market!

A sunloving, field grown plant that does well for plant sales include all the different species of *Echinacea*, including *angustifolia, purpurea, and pallida*. The most common use for Echinacea right now is to help boost the immune system to prevent catching colds and the flu. Skullcap (*Scutellaria lateriflora*) is in demand as transplants for a field crop. It is easily grown from seeds. Skullcap is used as a sedative and to treat headaches. Calendula *Calendula officinalia)* is a very attractive herb, commonly used in home herb gardens but also grown in large acreages. It is easily grown from seed. Calendula is valued for its wound healing properties.

If you decide that you want to get into the medicinal herb plant business, you need to know what is happening in the industry. My first recommendation is that you subscribe to some of the more popular herb publications. The demand for various herbs can change rapidly, and it is important to keep abreast of what is happening in the industry. For information on the industry in general, with emphasis on retail, look at publications such as the "Business of Herbs" and the "Herbal Connection". Information of this sort on the wholesale and field grown medicinals is harder to come by, but "HerbalGram" and the trade publications for natural foods are good places to start.

There are extension specialists in many institutions, such as N.C. State, Purdue, and Virginia State, who have good information on herb production. Productions guides on ginseng and goldenseal and other information on herb production and seed sources are available on- line from N.C. State at www.ces.ncsu.edu/depts/hort/hil/spcrop. Other institutions also have information on line, such as the New Crop website at Purdue. While you are on the Web, be sure to check out the HerbNet at www.herbnet.com. That site could keep you busy for hours!

"ATTRAnews", the newsletter from the federally funded program called Appropriate Technology Transfer for Rural Areas, is a publication that is useful to anyone looking at commercial production of alternative crops.

Some of the companies buying herbs and contract growing also can provide some useful production information. And some seed companies who sell large volumes of herb seed provide technical assistance. For example, Johnny's Selected Seeds hired medicinal plant experts as consultants to help with their herb line and Richter's Herb Seeds holds a growers conference every year.

I also recommend that you join local and national herb associations. For example, the International Herb Association provides good networking opportunities, holds a national conference each year, and has regional chapters that can be a good source of information.

Currently the market is strong for medicinal herbs so many growers are jumping into it. But the ones that stay with it and find it profitable will be the ones who do their homework, grow a quality plant, and provide the service and prices the market demands.

(This is the script for a talk prepared by Jeanine M. Davis and presented by Richard E. Bir at the International Plant Propagators Society Meeting in Newport, RI in October 1997) May also be found in the Combined Proceedings International Plant Propagators Society 1997 47:39-41

Cannabaceae

Hemp

Description

The scientific name of the hemp plant is Cannabis sativa. Although other plant fibers used for cordage have incorrectly been called hemp, only the hemp plant yields true hemp.

The plant is an annual herb with angular, rough stems and alternate deeply lobed leaves. It may grow to 16 feet (5 meters) tall, though plants cultivated for fiber are densely sowed and generally reach heights of only 7 to 10 feet (2 to 3 meters). The flowers are small and greenish yellow; male and female flowers grow on separate plants. The plant's slender woody stalks are hollow except at the tip and base.

Cultivation

Nutrition

For millennia the hemp plant has been cultivated for its strong, durable fiber. It is used for twine, yarn, rope, cable, and string, for artificial sponges, and for coarse fabrics such as sacking and canvas. In Italy it is used to make a fabric similar to linen. The plant is also grown for its seed--used in hempseed oil, paints, soaps, varnishes, and bird feed--and for its leaves and blossoms, used in medicinal preparations.

Fruit Trees

Few foods have as wide appeal as fruit. Fruits, which are the fleshy coverings for seeds, have been used as food since very early times.

In spite of their popularity, fruits are relatively unimportant as major nutritional items. Most fruits are juicy, with high water and sugar content, but contain few nutrients. They provide some vitamins and roughage and add variety and flavor to the diet. Fruits are selected largely for their agreeable taste.

The science and practice of growing fruit is called pomology. Fruits are relatively expensive because of their production and marketing costs. The steps include planting, care, harvesting, packing, storing, and shipping. Growing fruit in the home garden is a good way to have some at relatively low cost. Home gardeners who produce flowers and vegetables often balk at growing fruit because they think it demands too much space and is difficult. This may once have been true, but today there are many kinds of fruits that grow on bushes, vines, and dwarf trees that require little space and care. A dwarf plum or pear can provide both beauty and food. The blossoms on dwarf cherries and apples can equal those on flowering crab apple trees. Bramble fruit can replace hedges, while grapes can provide a shady arbor.

Tree fruit production, both commercial and in the home garden, has changed considerably since the early 1900s. After World War II, increased attention to gardening and the development of the science of pomology led to renewed interest in fruitgrowing. The introduction of dwarf trees and new systems of controlling growth made it feasible to have a fruit tree in an area as small as 25 square feet (2 square meters).

Dwarf fruit trees produce fruit early and abundantly. Relatively safe pesticides are now available to enable home gardeners to produce nearly blemish-free fruits.

Small fruits are especially improved. Some of the finest flavored fruits are homegrown because they can be ripened naturally and need not be shipped. Some choice varieties are delicate and cannot be grown commercially because they cannot tolerate the rough handling of harvesting and grading machines.

It is impossible to cover all the varieties of fruits or to list all the climatic conditions under which each grows best. For local information regarding the best varieties for use, it is advisable to contact governmental agencies, regional agricultural services, and schools of agriculture.

Kinds of Fruits

Fruits can be grouped as temperate, subtropical, and tropical on the basis of their climatic needs. There are, however, many other ways to classify fruits (see Fruit). Temperate-zone fruits grow on deciduous trees, which lose their leaves in the autumn. Tropical fruits grow on evergreen trees. Subtropical fruits grow on either deciduous or evergreen trees.

Temperate-zone fruits are further classified by structure as pome fruits, stone fruits, and small, or berry, fruits. Pome fruits, which have a core, include the apple, pear, and quince. Stone fruits, which have their seeds inside a hard pit, include the apricot, cherry, nectarine, peach, and plum. Berry fruits are a large group, including blueberry, brambles (raspberry, blackberry, and so on), bush fruits (currant and gooseberry), and cranberry (see Berry).

Subtropical and tropical fruits include avocado, banana, citrus (grapefruit, lemon, lime, orange, and others), date, fig, mango, papaya, persimmon, pineapple, and pomegranate. Some of these fruits are major crops in various parts of the world: avocado, banana, and plantain (a banana relative) are important foods in Central and South America; banana and citrus in Southeast Asia; date and fig in Asia Minor and the Near East; and breadfruit and coconut in scattered areas from the South Pacific Islands to the West Indies.

Cultivation

Tree fruits. In planting tree fruits commercially, the aim is to achieve the highest production with the least labor. Dwarf and semidwarf trees are planted close together in hedgerows, which are "walls" of trees that are supported by posts and wires. In home gardens such trees are given more space; the goal is usually superior quality.

In earlier times standard, or large, trees were grown commercially. The modern trend toward dwarf and semidwarf trees planted close together is one of many practices that allow machines to do much of the work. Varieties that require cross-pollination, however, have special needs in regard to spacing.

In commercial orchards certain dwarf trees can be as close as 5 to 6 feet (1.5 to 2 meters) apart in rows 14 feet (4 meters) apart. This spacing yields about 518 trees per acre. For home gardens more space is needed for maintenance, spraying, and picking.

Standard apples and pears need considerable room to grow, 35 to 45 feet (10 to 14 meters) from one trunk to the next. Dwarf apples and pears in home gardens can be planted as close as 10 feet (3 meters) apart. They often begin to bear fruit two years after planting. These trees are grafted onto special dwarfing rootstocks; care is taken when planting to keep the graft union above the soil line. Apple and pear trees need 32 to 36 inches (80 to 90 centimeters) of water per year, so in dry areas irrigation may be necessary. Pruning, or cutting some of the branches out, is minimal, restricted to removing dead and injured limbs and to removing inward-directed twigs. Fruits are borne on small twigs called spurs, which are produced on wood that is at least in its second year of growth. Pome fruits need cross-pollination, so a single planting requires at least two different varieties.

Stone fruit trees can be planted as close as 15 feet (4.5 meters) apart and pruned heavily to keep them small. If allowed to grow to their full size, standard peaches, plums, and sour cherries require distances of 18 to 25 feet (6 to 8 meters), and sweet cherries and apricots 25 to 40 feet (8 to 12 meters).

Cherry and peach trees grow best on cultivated land kept free of other plants. Apricots and plums are not as selective. Where annual rainfall is less than 30 inches (75 centimeters), commercial orchards of stone fruits are irrigated.

Unlike pome fruits, stone fruits may produce fruits on branches that are a year old. Most peach and apricot varieties are self-pollinating, as are sour cherries. Therefore, a planting does not need two different varieties. Most sweet cherries, however, must receive pollen from another sweet cherry variety in order to set fruit. Among the plums, most American and Japanese plums need to be cross-pollinated; some European plums also require this, but others do not.

All citrus fruit trees are injured by freezing, so their growing range is restricted to warm climates. The sweet orange is consumed in larger quantities than any other fruit. An orange tree needs about 400 square feet (36 square meters) of space in which to grow. Grapefruit trees need a little less space, lemon and lime trees a little more. Citrus trees do not need as deep soil as deciduous fruit trees, 3 feet (1 meter) being sufficient for maximum yield. Most of them are self-pollinating. They require 36 to 48 inches (90 to 120 centimeters) of water annually. Fruiting occurs during the winter and early spring.

Small fruits, including the berry and bush fruits, can be grown in beds or in rows. Grapes are spaced from 7 to 10 feet (2 to 3 meters) apart. On a fence or wall, a grape plant is given about 60 square feet (6 square meters) of space in which to spread its vines. Grapes need sun for at least half the day. Most modern grape varieties are self-fertile, but some provide better fruit when they are cross-pollinated with another variety.

Strawberries are of two basic types: everbearing, which yields fruit over a long period; and the single-crop, or June-bearing, which provides a heavier concentration of fruit in early summer. Strawberries can be planted 18 inches (45 centimeters) apart in rows that are 2.5 to 4 feet (0.75 to 1.25 meters) apart. The runners of strawberry plants, from which new plants will develop, are removed during the first season to make the plants strong. The second year they are allowed to spread. Commercial plantings of strawberries are allowed to bear fruit for two years and then are discarded. In home gardens they can bear well for five or six years. Some old varieties require cross-pollination; newer ones are self-fruitful.

Bramble fruits include red, golden, black, and purple raspberries; erect blackberries; and trailing blackberries such as boysenberries, dewberries, loganberries, and youngberries. Most production is in cool areas. Except for a few everbearing red raspberries, they are prickly perennial shrubs with canes that bear fruit the second year and then die back.

Both red and black raspberries and erect blackberries are spaced approximately 3 to 3.5 feet (about 1 meter) apart. They are grown in rows 6 to 10 feet (2 to 3 meters) apart.

Brambles do well in soil with high organic matter, and dressings of manure or compost increase the yield. They are deep-rooted and so do not require irrigation as critically as do strawberries, for example. All commonly used varieties are self-fruitful and do not require pollinators such as bees.

Canes that have fruited, weak canes, and suckers between rows are removed by pruning. Strong, long canes can be cut back somewhat or tied to supports.

Many blueberries are harvested from the wild. Highbush and rabbiteye blueberries are grown widely in gardens. They grow best in acid soil and in areas of cool summers and mild winters. They need full sun and much moisture to do their best. Each highbush blueberry needs 30 square feet (3 square meters) of space; each rabbiteye needs 40 to 60 square feet (4 to 6 square meters). They are not tolerant of drought. Mulching helps retain moisture if necessary. Blueberries seem to do better when cross-pollinated, so a planting normally has at least two different varieties. Blueberries tend to produce too much fruit, which limits fruit size and increases time to maturity. Some flower buds are removed by growers to allow large berries to be produced in a shorter time.

Melons, including cantaloupe, muskmelon, honeydew, and watermelon, require at least 120 warm or hot days to mature. They are reasonably drought-resistant. In commercial plantings they are picked just short of full ripeness. In home gardens they are picked when they slip off the stem easily. Muskmelon and its relatives are spaced 3 to 5 feet (1 to 1.5 meters) apart in hills, or groups of two to three plants each. Watermelons in hills of two to three plants are given 80 to 100 square feet (7 to 9 square meters).

General Care

Care in commercial plantings is intensive and highly mechanized, from spraying and pruning to harvesting and grading. The close spacing makes it necessary to spray efficiently and to utilize mechanical devices that provide maximum yields. Fruit trees and small fruits in the home garden need care but not much more than do other garden plants.

Soils around fruit plantings can be kept free of weeds through cultivation or chemical control. Unless weeds are kept out, they will compete for water, nutrients, and, in the case of low-growing fruits, light. Cultivation is done with hand hoes or with tilling machines. Herbicides, or chemical weed killers, are effective and in wide use in commercial plantings. In home plantings tree fruits are generally grown in grass-covered ground. Grass growing under fruit trees, however, slows down their growth and vigor.

Water is essential for good growth. To lessen water loss from the soil by evaporation, mulches are widely used. These are materials spread on the ground around the trees. They can be organic--such as wood chips, cocoa bean hulls, or crushed corn cobs; or inorganic--such as stones or plastic coverings.

Some fruit plants require pollen from related but different varieties. For this reason many fruit growers maintain beehives near their fruit plantings or rent them during flowering periods.

Thinning, or removing flowers of very young fruit, is a common practice in fruitgrowing. The remaining fruits become larger and develop more rapidly. It can be done by hand, mechanically, or chemically.

Pest control is probably the most expensive and time-consuming operation in fruitgrowing. Increasingly, integrated pest management is practiced. This is the combined use of biological controls (pests of pests) on a long-term basis and chemicals only in case of a pest flare-up. Both cost and damage to the environment are greatly reduced by this method.

Harvesting

Good records of past years' production in commercial plantings are helpful in predicting the time of harvest. Scheduling of work and processing of fruit also depend on such data, as does the efficient use of equipment and labor.

The oldest harvesting technique is hand picking, which is still common. Commercial operations revert to hand picking when machines are not available or when their cost and feasibility are questionable. Machines have been devised to collect even the most easily bruised fruits. Plant breeders have developed crops that ripen uniformly, grow compactly, do not bruise easily, and hang freely or extend beyond the foliage for easier picking.

Some machines used commercially are motor-driven tree and bush shakers that have catching belts to slow fruit fall and also have storage capacity. There are also finger-type mechanical pickers, slappers, and paddles of ingenious engineering. In large orchards machines may pick, sort, clean, grade, and pack fruit in a continuous operation (see Farm Machinery).

Processing, Storage, and Shipping

Fruits are washed or brushed to improve their appearance. Cooling slows the rate of respiration, slows shriveling, and inhibits decay. Costs can be cut by harvesting at night and in early morning while the crop is at its lowest temperature. After fruits are cooled, they must be kept cool during shipment.

Uniformity in quality, size, shape, color, and ripeness is sought because of consumer preference and because automated machines can handle quantities of uniform fruit with greater ease. Grades are established by law and are used to describe the produce. They are Extra Fancy, Fancy, No. 1, No. 2, and so on.

Most fruits are packaged in retail units before reaching stores. Wooden crates and baskets are declining in favor of trays and cartons of styrofoam, wood pulp, or cardboard designed for easy stacking and shipping and for minimal bruising.

Although most fruits are eaten raw and are enjoyed locally, some are preserved first through a variety of treatments such as drying (raisins, prunes, dates), cooking in syrup (candied fruits, jellies, preserves), and exposing to sulfur dioxide (apricots, prunes, maraschino cherries). Fruits can also be canned, frozen, dehydrated, pickled, fermented, and made into concentrates and preserves.

Storage of fruits not specially processed requires post-harvest treatment so that crops can be sold over an extended period. The best storage slows life processes but avoids deterioration. Some techniques for storage include a controlled atmosphere in which oxygen and carbon dioxide are kept at optimal levels, usually 5 percent oxygen and 1 to 3 percent carbon dioxide. Also, low temperatures decrease respiration, and controlled humidity slows water loss.

Storage temperatures and humidity differ for each type of fruit. Most deciduous fruits can be kept at 32o to 41o F (0o to 5o C). Subtropical and tropical fruits cannot be held long under such temperatures without showing injury. Bananas, for example, will not tolerate temperatures under 53o F (12o C) without deteriorating rapidly. (See also Food Processing.)

World Production

World production of apples exceeds 39 million tons (35 million metric tons) annually. Europe is the leading applegrowing continent, where much of the crop is processed as a mild alcoholic cider. Elsewhere the apple crop is sold mainly for eating fresh, but a good portion is converted to apple butter, jelly, applesauce, cider, and cider vinegar.

Total world production of pears exceeds 8 million tons (7 million metric tons) annually, mainly from Italy. Pears are used fresh and canned and in Europe are crushed for cider and for winemaking.

The world's peach and nectarine production is about 8 million tons (7 million metric tons) annually. The United States and Italy are the leading peach and nectarine growers. Europe accounts for most of the world's plum production, which is more than 6 million tons (5.5 million metric tons) annually.

Production of cherries exceeds 1.5 million tons (1.4 million metric tons) annually, mainly from Italy, Germany, France, the United States, and Turkey. About 1.7 million tons (1.5 million metric tons) of apricots are produced, with southern Europe, North Africa, the Middle East, and California the leaders. Except for grapes, exceeding 72 million tons (65 million metric tons), the annual production of other small fruits is less than a million tons each. [26]

Bee Keeping

Beekeeping is the care and management of colonies of honeybees. They are kept for their honey and other products or their services as pollinators of fruit and vegetable blossoms or as a hobby. The practice is widespread: honeybees are kept in large cities and villages, on farms and rangelands, in forests and deserts, from the Arctic and Antarctic to the Equator.

In antiquity people knew that bees produce delicious honey, that they sting, and that they increase their numbers by swarming. By the 17th century they had learned the value of smoke in controlling them and had developed the screen veil as protection against stings. From the 17th to the 19th century, the key discoveries upon which modern beekeeping is founded were made. These included the mystery of the queen bee as the mother of nearly all the occupants of the hive, her curious mating technique, parthenogenetic development, the movable frame hives, and the fact that bees rear a new queen if the old one disappears.

Given this knowledge people were able to divide a colony instead of relying on natural swarming. Then the development of the wax-comb foundation, the starter comb on which bees build straight, easily-handled combs, and the discovery that honey can be centrifuged or extracted from them and the combs reused, paved the way for large-scale honey production and modern commercial beekeeping. The identification of bee diseases and their control with drugs, the value of pollen and pollen substitutes in producing strong colonies, and the artificial insemination of queens have increased the honey-production efficiency of colonies.

HONEYBEES AND THEIR COLONIES

Honeybees.

Honeybees belong to the order Hymenoptera and to one of the *Apis* species. (For a complete discussion of honeybees, see the article INSECTS: *Hymenoptera [ants, bees, sawflies, wasps, and allies]*.) Honeybees are social insects noted for providing their nests with large amounts of honey. A colony of honeybees is a highly complex cluster of individuals that functions virtually as a single organism. It usually consists of the queen bee, a fertilized female capable of laying a thousand or more eggs per day; from a few to 60,000 sexually undeveloped females, the worker bees; and from none to 1,000 male bees, or drones. The female of most species of bees is equipped with a venomous sting.

Honeybees collect nectar, a sugary solution, from nectaries in blossoms and sometimes from nectaries on the leaves or stems of plants. Nectar may consist of 50 to 80 percent water, but when the bees convert it into honey it will contain only about 16 to 18 percent water. Sometimes they collect honeydew, an exudate from certain plant-sucking insects, and store it as honey. The primary carbohydrate diet of bees is honey. They also collect pollen, the dustlike male element, from the anthers of flowers. Pollen provides the essential proteins necessary for the rearing of young bees. In the act of collecting nectar and pollen to provision the nest, the bees pollinate the flowers they visit. Honeybees also collect propolis, a resinous material from buds of trees, for sealing cracks in the hive or for covering foreign objects in the hive that they cannot remove. They collect water to air-condition the hive and to dilute the honey when they consume it.

A populous colony in a desirable location may, in a year's time, collect and carry into the hive as much as 1,000 pounds (450 kilograms) of nectar, water, and pollen.

[26]Excerpted from *The Complete Reference Collection*. Copyright © 1994, 1995, 1996, 1997 The Learning Company, Inc. All Rights Reserved.

Bees secrete beeswax in tiny flakes on the underside of the abdomen and mold it into honeycomb, thin-walled, back-to-back, six-sided cells. The use of the cell varies depending on the needs of the colony. Honey or pollen may be stored in some cells, while the queen lays eggs, normally one per cell, in others. The area where the bees develop from the eggs is called the broodnest. Generally, honey is stored toward the top of the combs and pollen in cells around the broodnest below the honey.

The bees maintain a uniform temperature of about 93 F (34 C) in the broodnest regardless of outside temperature. The colony can survive daily maximum temperatures of 120 F (49 C) if water is available with which they can air-condition the cluster. When the temperature falls below about 57 F (14 C) the bees cease flying, form a tight cluster to conserve heat, and await the return of warm weather. They can survive for several weeks in temperatures of -50 F (-46 C).

When summer flowers bloom in profusion, the queen's egg-laying is stimulated, the cluster expands, and honey accumulates in the combs. When the large number of young bees emerge, the domicile becomes crowded.

When the colony becomes crowded with adult bees and there are insufficient cells in which the queen can lay large numbers of eggs, the worker bees select a dozen or so tiny larvae that would otherwise develop into worker bees. These larvae are fed copiously with royal jelly, a whitish food with the consistency of mayonnaise, produced by certain brood-food glands in the heads of the worker bees. The cell in which the larva is developing is drawn out downward and enlarged to permit development of the queen. Shortly before these virgin queens emerge as adults from their queen cells, the mother queen departs from the beehive with the swarm. Swarming usually occurs during the middle of a warm day, when the queen and a portion of the worker bees (usually from 5,000 to 25,000) suddenly swirl out of the hive and into the air. After a few minutes' flight, the queen alights, preferably on a branch of a tree but sometimes on a roof, a parked automobile, or even a fire hydrant. All the bees settle into a tight cluster around her while a handful of scouts reconnoitre a new homesite.

When the scout bees have located a new domicile, the cluster breaks, the swarm takes to the air and in a swirling mass proceeds to the new home. Swarming is the bees' natural method of propagation or increase.

Back in the parent colony, the first queen to emerge after the mother queen departs with the swarm immediately attempts to destroy the others. If two or more emerge at the same time, they fight to the death. When the surviving virgin is about a week old, she soars off on her mating flight; she frequently mates with more than one drone while in the air. She may repeat the mating flights for two or three successive days, after which she begins egg laying. She rarely ever leaves the hive again except with a swarm. Normally, sufficient sperm are stored in her sperm pouch, or spermatheca, to fertilize all the eggs she will lay for the rest of her life. The drones die in the act of mating.

The queen can live up to five years, although many beekeepers replace the queen every year or two. If she is accidentally killed or begins to falter in her egg-laying efficiency, the worker bees will rear a "supersedure" queen that will mate and begin egg laying without a swarm emerging. She ignores the mother queen, who soon disappears from the colony.

Worker bees.

Worker bees live about six weeks during the active season but may live for several months if they emerge as adults in the fall and spend the winter in the cluster. As the name implies, worker bees do all of the work of the hive, except the egg laying.

Drones.

Drones are reared only when the colony is populous and there are plentiful sources of nectar and pollen. They usually live a few weeks, but are driven from the hive to perish when fall or an extended period of adversity comes upon the colony. The only duty of the drone is to mate with the queen.

The queen can lay drone (unfertilized) eggs in the drone cells. If she is not allowed to mate or if her supply of sperm is exhausted, she will lay unfertilized eggs in worker cells. The development of unfertilized eggs into adult drones is known as parthenogenesis. Occasionally a colony may become queenless and unable to develop another queen. Then, some of the worker bees begin to lay eggs, often several to a cell, and these develop into drones. A colony that has developed laying workers is difficult to requeen with a laying queen.

COLONY MANIPULATION

The yearly work cycle.

The beekeeper's year starts in early fall. At that time he requeens the colonies whose queens are not producing adequate amounts of brood and makes sure that each colony has sufficient stores: at least 50 pounds (22 kilograms) of honey and several frames filled with pollen. Some beekeepers also feed the drug fumagillin to reduce possible damage to the adult bees by nosema disease (see below *Disease and pest control*). The colonies need a sunny exposure and protection from cold winds. Some beekeepers in northern and mountainous areas wrap their colonies with insulating material in winter. A few beekeepers kill their bees in the fall, harvest the honey, store the empty equipment, then restock with a two- or three-pound (0.8- or 1.4-kilogram) package of bees and a young queen the following spring.

If the colonies are well prepared in the fall they need little attention during the winter. But in early spring, an examination of the colonies by the beekeeper is important. Frequently, strong colonies exhaust their food supply and starve only a few days before flowers begin to bloom in abundance. Only a few pounds of sugar syrup, 50-50 sugar water, or a honey-filled comb from another more prosperous colony might save such a starving colony. Again fumagillin may be fed to the colony, and some beekeepers also feed a cake of pollen substitute or pollen supplement. Honey is not fed to the colonies unless the beekeeper is sure about its source. Honey from colonies affected by the brood disease American foulbrood could infect his colonies and cause a serious loss.

As the spring season advances, the cluster size increases from the low population of 10,000 to 20,000 bees that survived the winter. To accommodate the increased size of the cluster and broodnest, the keeper adds more supers, or boxes of combs. If the combs are so manipulated that the queen can continually expand her egglaying area upward, the colony is unlikely to swarm. This can be achieved by placing empty combs or combs in which brood is about ready to emerge at the top of the cluster and combs filled with eggs or young brood toward the lower part of the broodnest. The beekeeper wants the colony to reach its peak of population, 50,000 to 60,000 bees, at the beginning of the major nectar flow.

The bees in a swarm, having departed the hive with a full stomach of honey, rarely sting. The usual way to capture them is to place a hive or upturned box beneath or nearby, then shake or smoke the bees to force the queen and a majority of the bees into it. The others follow. After the swarm is safely inside the box it can be removed to a permanent location.

Regulations governing the keeping of bees usually require the bees to be kept in hives with movable combs. If the bees are captured in a box they are generally transferred into a movable-frame hive within a few days so the new honey and comb will not be lost in the transfer.

Requeening a colony.

When a beekeeper requeens a colony, he removes the failing or otherwise undesirable queen and places a new one in a screen cage in the broodnest. After a few days the colony becomes adjusted to her and she can be released from the cage. A strange queen placed in the cluster without this temporary protection usually will be killed at once by the workers. Queens usually are shipped in individual cages of about three cubic inches (50 cubic centimetres) with about half a dozen attendant bees and a ball of specially prepared sugar candy plugging one end of the cage. When the cage is placed in the hive, the bees from both sides eat the candy. By the time the candy is consumed and the bees reach each other, their odours have become indistinguishable, the queen emerges from the cage into the colony and begins her egglaying duties.

Standard tools of the beekeeper are: the smoker to quell the bees; a veil to protect the face; gloves for the novice or the person sensitive to stings; a blunt steel blade called a hive tool, for separating the frames and other hive parts for examination; the uncapping knife, for opening the cells of honey; and the extractor, for centrifuging the honey from the cells.

Bee stings.

The worker bee sting is barbed, and in the act of stinging it is torn from the bee. It has a venom-filled poison sac and muscles attached that continue to work the sting deeper into the flesh for several minutes and increase the amount of venom injected. To prevent this, the sting should be scraped loose (rather than grasped and pulled out) at once. Bee stings are painful, and no one becomes immune to the pain. Immunity to the swelling is usually built up after a few stings, however.

Normal reaction to a bee sting is immediate, intense pain at the site of the sting. This lasts for a minute or two and is followed by a reddening, which may spread an inch or more. Swelling may not become apparent until the following day. Occasionally, acute allergic reactions develop from a sting, usually with persons who have other allergic problems. Such a reaction becomes evident in less than an hour and may consist of extreme difficulty in breathing, heart irregularity, shock, splotched skin, and speech difficulty. Such persons should obtain the services of a medical doctor immediately.

Honey production.

Honey is marketed in several different forms: liquid honey, comb honey, and creamed honey. Sometimes the predominant floral type from which the honey was collected is indicated.

Liquid honey.

If liquid (strained, extracted) honey is desired, additional supers are added directly above the brood nest. When one is largely filled, it is raised and another is placed underneath. This may continue until several have been filled, each holding from 30 to 50 pounds (14 to 23 kilograms), or until the nectar flow has ended. After the bees have evaporated the water until the honey is of the desired consistency and sealed in the cells, the combs are removed, the cells uncapped with the uncapping knife, and the honey extracted. The removed honey is immediately heated to about 140 F (60 C), which thins it and destroys yeasts that can cause fermentation. It is then strained of wax particles and pollen grains, cooled rapidly, and packaged for market. (see also *Index*: broodnest)

Comb honey.

In production of honey in the comb, or comb honey, extreme care is necessary to prevent the bees' swarming. The colony must be strong, and the bees must be crowded into the smallest space they will tolerate without swarming. New frames or sections of a frame with extra-thin foundation wax, added at exactly the right time for the bees to fill without destroying them, are placed directly above the brood nest. The bees must fill and seal the new comb to permit removal within a few days, or it will be of inferior quality. As rapidly as sections are removed, new sections are added, until the nectar flow subsides; then these are removed and the colony given combs to store its honey for the winter.

Creamed honey.

Almost all honey will granulate or turn to sugar. Such honey can be liquefied without materially affecting its quality by placing the container in water heated to about 150 F (66 C). Liquid and granulated honey is sometimes blended, homogenized, and held at a cool temperature, which speeds uniformly fine granulation. If properly processed, the granules will be extremely fine; the honey, which has a smooth, creamy appearance, is referred to as creamed honey.

Floral types.

Some honeys are sold by floral type; that is, they are given the name of the predominant flowers visited by the bees when they accumulated the honey. The beekeeper has no way to direct the bees to a particular source of food but through experience learns which plants are the major sources of honey. Different flowers produce different colours and flavours of honey. It may be heavy-bodied or thin-bodied, dark or light, mild-flavoured or strong-flavoured. Most honey has been blended by the beekeeper to a standard grade that can be supplied and marketed year after year.

World honey production statistics.

World production of honey was about 1,950,000,000 pounds (884,000,000 kilograms) in 1981. North America produced about 390,000,000 pounds (180,000,000 kilograms); the U.S.S.R., about 420,000,000 pounds (190,000,000 kilograms); and the remaining countries of the world, about 1,140,000,000 pounds (517,000,000 kilograms). The largest exporting countries were mainland China, Mexico, Argentina, and Australia. Although honey production per colony in the United States amounted to about 44 pounds (20 kilograms), when the colonies are properly manipulated and in good locations they frequently produce several times this amount. An average annual production of several hundred pounds per colony has been reported for a small isolated area of southwestern Australia.

Beeswax is a by-product of beekeeping in most areas. When beekeepers uncap or break honeycombs or have unusable combs, they try to salvage the beeswax. First, they recover as much honey from the combs as possible by drainage or extraction. Then they place the material in water heated to slightly over 145 F (63 C). This melts the wax, which rises to the surface. After it cools and hardens, the cake of wax is removed and refined for reuse in comb foundation. Beeswax has many other uses: in quality candles, cosmetics, agriculture, art, and industry. In some areas bees are manipulated primarily for wax production. Wax is a highly stable commodity that can be transported long distances under unfavourable conditions without damage.

Queens are reared for sale to other beekeepers for requeening established colonies or for adding to a two- or three-pound (0.9- or 1.4-kilogram) package of 8,000 to 10,000 live bees to form new colonies or replenish weak ones. The queens are produced when the beekeeper cages the reigning queen in a colony, then inserts into the cluster from 30 to 60 queen cell bases into which young (one-day-old) worker larvae have been transferred. More than 1,000,000 queens are produced in this way and sold each year in the United States. Queens can be artificially inseminated with sperm from drones of a known source, but most beekeepers let the queens mate naturally.

The live bees are shaken from the combs of the colony through a funnel into screen-wire cages. About 500 tons of live bees are produced for sale annually in the United States, primarily in the southeastern states and California. Several tons are shipped annually from the United States to foreign countries, primarily to Canada.

The greatest value of bees is in their service as pollinators. Some 90 crops grown in the United States alone are dependent on insect pollination, performed primarily by the honeybee. The average colony of bees is worth from 20 to 40 times as much in the pollination of crops as it is in the production of honey. The value of bees in the pollination of ornamental plants has never been calculated. Bees are also valuable in the pollination of some forest and range plants that produce seeds on which birds and other wildlife feed.

When bees are used in the pollination of crops, the beekeeper places the colonies within or adjacent to the field to be pollinated. The majority of the roughly 1,000,000 colonies that are used for pollination are used in alfalfa-seed fields and almond and apple orchards. The colonies are distributed at the rate of two or more per acre in groups every 0.1 mile (0.16 kilometre) throughout alfalfa fields. Two colonies per acre are recommended for almond orchards and about one colony per acre in apple orchards.

Some growers prefer to have the colonies placed alongside the orchard; others want them distributed in small groups within the orchard. Bees also are used regularly by growers of many other crops: blueberries, cantaloupes, cherries, clovers, cucumbers, cranberries, cutflower seed, plums and prunes, vetch, and watermelon.

DISEASE AND PEST CONTROL

Honeybees have diseases and enemies: diseases of the brood; diseases that affect only the adult bees; insect enemies of the adults and of the comb; and other enemies, including toads, lizards, birds, mice, skunks, and bears.

Diseases.

American foulbrood, caused by a spore-forming bacterium, *Bacillus larvae,* is the most serious brood disease. It occurs throughout the world wherever bees are kept and affects workers, drones, and queens. The spores are highly resistant to heat and chemicals. A comb containing brood severely infected with this disease has a mottled appearance caused by the mixture of healthy capped brood interspersed with diseased or empty cells formerly occupied by diseased brood. The decayed mass has a typical ropiness when dug into, which is one of its identifying characteristics.

American foulbrood can be spread to healthy colonies by transferring equipment or allowing the bees to feed on honey from infected colonies. Sulfathiazole and Terramycin are widely used to control the disease. Many countries and most states in the U.S. require the destruction by fire of diseased colonies and have apiary inspectors to enforce the regulations.

European foulbrood is caused by a nonsporeforming bacterium, *Streptococcus pluton,* but *Bacillus alvie* and *Acromobacter eurydice* are often associated with *Streptococcus pluton.* This disease is similar in appearance to American foulbrood. In some instances it severely affects the colonies, but they recover so that colony destruction is not necessary. Terramycin can control the disease.

Sacbrood is caused by a virus and is superficially similar to the foulbrood diseases. It can appear and disappear spontaneously but is seldom serious. No chemical control is needed, but if the problem persists the beekeeper usually requeens the colony.

Chalk brood is caused by the fungus *Ascosphaera apis.* The larvae victims of this disease have a chalky, white appearance.

Stonebrood, which affects both brood and adults, is also caused by a fungus, *Aspergillus flavus,* which can usually be isolated from bees that have stonebrood.

Nosema disease, caused by the protozoan *Nosema apis,* is the most serious disease of adult bees. It is widespread, causes heavy losses in honey production, and severely weakens colonies. The external symptoms of bees with nosema disease are not apparent. The disease is transmitted from adult to adult by ingestion of the spores that soon germinate in the ventriculus, or main, stomach. An infected ventriculus is normally swollen, soft, and grayish white. A degree of control may be obtained by feeding the colony the drug fumagillin.

Acarine disease is caused by the mite *Acarapis woodi* that gets into the tracheae of the bee through its breathing holes or spiracles in its thorax or midsection. Bees affected by this mite are unable to fly, have disjointed wings and distended abdomens. There is presently no good control for this mite. The only U.S. federal law pertaining to bees was passed to prevent the importation of adult bees carrying this mite into the United States. Two other mites, *Varroa jacobsoni* and *Tropilaelops clareae,* are serious problems of Asian beekeepers, but they do not occur in Europe or North America.

There are other minor diseases of adult bees, but they seldom cause serious problems.

Pests.

The greater waxmoth, *Galleria mellonella,* is a lepidopterous insect that, in its larval stage, destroys combs. It does not attack adult bees, but may begin destruction of combs of a weak colony long before the bees are gone. It can also destroy stored combs of honey. When the larvae are ready to pupate they often eat out a place to spin their cocoons in the soft wood of the beehive, damaging frames and other hive parts. The best control for this pest is keeping colonies strong. Stored combs are fumigated, kept in a cold room or stacked in such a way that a strong air draft flows around them. (see also *Index*: pest control, wax moth)

The larvae of the lesser waxmoth, *Achroia grisella,* cause damage to stored combs similar to that of the greater waxmoth. The Mediterranean flour moth larva, *Anagasta kuehniella,* feeds on pollen in the combs and causes some damage. Control for both of these moths is the same as for the greater waxmoth.

The bee louse, *Braula caeca,* is a tiny, wingless member of the fly family that is occasionally found on bees, but feeds on nectar or honey from the mouthparts of its host. Its larvae burrow in the cappings of honey combs.

Ants sometimes invade hives and disrupt or kill the bees.

Termites can damage or destroy hive parts placed on the soil.

Other insects, such as dragonflies (Odonata), robberflies (Diptera), praying mantises (Orthoptera), ambush bugs (Hemiptera), and certain wasps and yellow jackets (Hymenoptera) are natural enemies of the honeybee.

Predators.

Mice frequently enter the hive in winter when the bees are clustered, or they get into stored combs and despoil or damage them by chewing the frames and combs to construct their nest. (see also *Index*: mouse)

Skunks devour large numbers of bees at the hive entrance, usually at night. Fences, traps, and poison are used against them.

Bears eat the honeybees and brood in the hive, and usually destroy it and its contents in the process. In bear country, electric fences and traps are used to protect bee colonies.

At times bees become their own deadly enemy. If honey is exposed to them when no flowers are in bloom and the weather is mild, the bees from different colonies will fight over it. Sometimes this fighting, or robbing, becomes intense and spreads from hive to hive in moblike action. If all the bees in one colony are killed, the honey is quickly stolen and carried into other hives. This further intensifies the robbing so that a cluster that was carrying honey into its hive a few minutes earlier is attacked, all of its occupants killed, the honey again stolen and the process repeated. Usually, once robbing becomes intense, only darkness or foul weather will stop it. (S.E.McG.)

White clover-based swards on Organic Units

Benefits of grass/clover swards compared to grass swards

Can produce similar dry matter yield as a grass sward receiving 200 kg of fertiliser nitrogen per hectare (6 bags of 27% nitrogen per acre)

Maintains high digestibility over longer period leading to improved intakes

Up to 10% higher liveweight gain in cattle, 20% more milk from dairy cows and 25% higher liveweight gain in sheep

Enhances lean meat gain and milk protein content

Contains more minerals, in particular magnesium, thereby reducing the risk of animal health problems associated with mineral deficiency

Saves on energy usage thereby indirectly reducing environmental pollution

Evidence of reduced nitrogen loss to the environment

Greater biodiversity

Clover is the key to grassland management

The provision of good levels of herbage production on organic units depends on achieving high clover contents in swards.

The ability of clover to capture nitrogen from the air is well known but the potential value of clover-based swards is often underestimated.

However, maintaining the high clover contents in swards required to achieve satisfactory levels of production needs careful sward management

Establishing clover

Choice of clover varieties

White clovers are classified according to leaf size:- small, medium, large and very large.

Small leaved varieties survive best under intensive sheep grazing as they have a creeping growth habit, but they can be expensive and some varieties can, at times, be in short supply.

Medium leaved varieties are generally tolerant of a wide range of conditions and should always be included in mixtures intended for all grazing use. Menna tends to be more winter hardy than Grassland Huia.

Large leaved varieties are for general purpose use best suited to rotational grazing by cattle or sheep or where some silage is taken.

Very large leaved varieties are high yielding but are least persistent under grazing and are best confined to hay or silage swards with only limited grazing use.

The best compromise is to use a mixture of clover varieties, half or which should be medium leaved and the remainder either small, medium or very large leaved varieties depending on the intended sward use.

The tables below show the most readily available recommended varieties in Northern Ireland.

Note: Varieties in bold type have performed best over many trials.

Small leaved	Relative leaf size (% of Huia)	Clover yield potential	Grazing persistence (0-9)
Control yield (tonnes DM/ha)		2.1	
Kent Wild White	43	61	6.2
Aberystwyth S184	65	84	5.9
Tara	68	86	6.3
Gwenda	71	120	5.9
Grasslands Demand	79	97	6.2
Grasslands Tahora	59	73	5.7

Medium leaved	Relative leaf size (% of Huia)	Clover yield potential	Grazing persistence (0-9)
Control yield (tonnes DM/ha)		2.1	
Avoca	92	113	5.4
Menna	93	116	4.8
Grasslands Huia	100	93	5.2
AberHerald	91	107	4.3
AberDai	99	152	4.8
AberVantage	99	123	4.2

Large leaved	Relative leaf size (% of Huia)	Clover yield potential	Grazing persistence (0-9)
Control yield (tonnes DM/ha)		2.1	
Sterling	112	101	4.9
Alice	119	138	4.5
Milkanova	128	93	4.1

Very large leaved	Relative leaf size (% of Huia)	Clover yield potential	Grazing persistence (0-9)
Control yield (tonnes DM/ha)		2.1	

Aran	159	143	3.4

Choice of companion grass for clover

Intermediate heading perennial ryegrass, particularly some tetraploid varieties, are the best companion grasses for clover. Varieties need to be selected with care.

Select erect, less aggressive types such as Aberelan, Merbo and Portstewart, that develop a sward structure which will help encourage the spread of clover

Tetraploid varieties such as Bastion/Labrador, Rosalin/Fetione and Tivoli/Elgon may assist in maintaining an open sward, which should help to promote a higher clover content

Hybrid ryegrass varieties, which combine the characteristics of perennial and Italian ryegrasses, should encourage clover development due to their more open structure

When reseeding on heavy soils it may be worth replacing 2-3 kg of perennial ryegrass with Timothy, such as Erecta, Comtal or Motim

The inclusion of herbs, such as chicory or sainfoin, can also be considered on organic units. Although many herbs will germinate and grow quite readily in reseeds they can be difficult to maintain over time and add to the cost of seed mixtures. They are deep rooting and provide a rich source of minerals to grazing livestock.

When the primary use of a sward is silage rather than grazing the use of red clover with Italian and hybrid ryegrasses could be considered.

Establishing clover-rich swards

There are several ways of achieving clover-rich grass swards:

Direct reseeding

Undersowing

Strip or slot seeding

Minimal cultivation

Slurry seeding

Pasture management to encourage existing clover

Direct reseeding before the end of August is the most reliable method of establishing grass/clover swards. To ensure a good establishment of clover, be generous with the clover seed and economise on the grass seed.

The best compromise is about 25 kg of perennial ryegrass with 4-5 kg of clover seed, sown at about 29-30 kg per hectare. The seedbed should be firm and fine and should be rolled prior to sowing the grass/clover mixture.

Undersowing can be useful for spring reseeds, using early maturing spring cereal varieties as the cover crop.

Existing swards can be upgraded using specialist strip or slot seeding but the technique has given variable results under local conditions.

A range of methods are available for placing seed into a sward, such as direct drilling using the Vertikator, Moore Unidrill, or discing ground and broadcasting the seed.

In all cases it is essential that grass cover is minimised by grazing the sward tightly (4-5 cm; 1.5-2") in late July.

Alternatively, follow in immediately after a silage cut taken mid-July or late August, when soil conditions are neither excessively wet or dry.

Minimal cultivation represents an alternative to strip or slot seeding in that the technique does not involve ploughing. If discing, set the disc with minimum cut (coulters running straight) and add weight.

Disc the field in several directions to open up slits in the ground before sowing when soil conditions are dry. Roll after sowing to achieve good seed to soil contact, conserve moisture and ensure rapid germination.

Slurry seeding may be an option in circumstances where the existing sward has become thin and in need of rejuvenation.

Pasture management to encourage clover can have a significant impact provided clover is well distributed throughout the field at the outset.

Key factors in reseeding

All the basic principles for any reseeding operation must be considered as part of an overall sward improvement programme, for example, adequate drainage, pH, fertility, weed and pest control.

A routine programme of soil analysis to keep a check on soil fertility is worthwhile every 3 – 5 years.

Soil analysis should be taken from any fields which are to be reseeded. Aim to maintain a soil pH status of 6.0-6.5. Lime can be used to correct soil pH.

In addition to manure and slurry some natural sources of phosphate and potash, such as ground rock phosphate and rock potash, can be used to maintain soil fertility.

For successful clover establishment, by any method, there are some principles that must be adhered to:

Correct timing

Late summer (August) is best for seed germination and full plant development before winter

Proper soil fertility

Soil phosphate and potash status should both be at least 2 and soil pH should be between 6.0 and 6.5

Good seed/soil contact

Seeds need to be placed into a firm, shallow (1-2 cm) seedbed

Control grass competition

The existing grass sward cover must be kept low before and after seed sowing, otherwise the young seedlings will not survive

Encouraging clover in existing swards

Provided clover is well distributed throughout the field, even though it may not be contributing much to sward productivity, it may be possible to encourage the development of a productive clover rich sward without the need to reseed.

To determine the suitability of a field for rejuvenation there must be a high proportion of productive grass species present and a clover assessment should be carried out.

As you walk across a field you must see clover within 0.5 m (20") of your foot in 8 out of every 10 inspections, preferably carried out every 20 paces over the entire area of the field.

If there is an even distribution of clover throughout the sward, then proceed to adopt the management guidelines given below:

Grazing hard (3-5 cm, 1-2") with sheep or light cattle during November/December

Avoid undergrazing during spring/early summer

Resting for 3-4 weeks during July or closing off for silage

Avoid poaching

Avoid smothering with slurry

Control broad leaved weed development

Weed control

In direct sown swards or swards undersown in an arable silage crop, topping or forage harvesting can control many weeds.

Grazing with sheep whenever the grass is 10 cm (4") tall can provide a useful degree of control of annual weeds, for example, chickweed, hempnettle and redshank, and of ragwort in established swards.

However, care must be taken to avoid overgrazing and poaching, especially when soil conditions are wet. Periods of frost can provide an opportunity to graze with minimal damage.

Thistles do not survive long if repeatedly topped before flowering. Docks are the most difficult weed to control in an organic system.

Research work is in progress at ADAS Redsdale in an effort to find means of controlling dock in organic systems.

Pest and disease control

A number of pests can attack clover plants but routine control measures are not considered worthwhile.

Clover is even more susceptible to leatherjackets than grasses, although clover will eventually recover after most attacks.

Although a number of diseases can affect both white and red clover there are no routine recommendations for their control.

Bloat

Bloat can occur in both beef and dairy cattle grazed on lush clover-rich swards. However, the condition can also occur on all-grass swards.

As part of normal rumen function the large volumes of gas normally produced are belched and the animals suffer no discomfort.

However, when bloat occurs a stable froth is produced which inhibits both normal belching of the gas and rumen contractions.

Sub-clinical and clinical bloat can affect productivity, while in severe cases death can result from heart failure and from asphyxia.

Prevention

Feed roughage, such as straw or hay, before turning out and if necessary during grazing

Sheep selectively graze clover and are not prone to bloat. Grazing sheep ahead of cattle reduces the risk

Never allow hungry cattle to gorge themselves on clover-rich pasture

Cattle moved onto dry rather than wet pasture are at less risk

Affected animals may be treated with anti-foaming agents

In severe cases remove animals from clover swards and seek veterinary advice

Fluctuations in production

The productivity of grass/clover swards can be more variable, both within and between seasons, when compared to grass swards dependent on inorganic nitrogen fertiliser.

Clover-based swards are slow to start growing in the spring. Early growth can be encouraged through strategic use of slurry and farmyard manure. It is important that the resultant flush of grass is grazed down efficiently to allow subsequent growth and development of clover within the sward.

Target clover content

In most situations the clover content of swards is at its peak from late July to mid-August. The spring target should be 30% ground cover, indicating that adequate clover has survived the winter and that it will be able to compete with grasses that grow more quickly than clover in spring. Ground cover is the proportion of the ground covered with clover leaves.

By mid-June, clover ground cover should be increasing to about 40%. A peak of 50-60% clover ground cover is required by early August. This results in the best compromise between the quantity of herbage produced per hectare and the nutritional value of the herbage.

If the clover content is very high, overall yield decreases, since there is not enough grass to utilise the nitrogen fixed by clover. While the nutritional value of the available herbage rises the risk of bloat in cattle is also increased. However, too little clover will eventually result in poor production.

The proportion of clover required to improve individual animal performance depends on the type of stock and the grazing system adopted.

For example, sheep in rotationally grazed swards can show enhanced performance with an average clover cover of 20-30% over the season, due to their ability to selectively graze clover.

In set-stocked systems sheep performance has benefited from the presence of a lower content of clover (less than 20% cover) over the season.

In cattle systems, swards need to contain 40-55 % average cover in order to enhance individual animal performance.

Production

Fact File Self-sufficiency guide[27]

This summarises how much to grow to feed a family of two adults and three children. Each of the rows is 4.5M (15ft) Long. Also included is advice on how much to harvest for each meal. Remember that it is always better to pick your crops fresh for each meal and eat them as soon as possible after harvesting. Leaf vegetable, in particular; begin to lose some of their nutritional value immediately they are harvested. If you have a surplus of a particular crop, don't allow it to get old and tough: gather it and freeze it while it is still young and tender or give it to friends.

Beans
Broad: 3 rows (plus one for the freezer, if needed), 45 cm apart, seeds 30cm (1ft) apart. Pick 340g (3/4lb) of pods when young for each adult, 226g (1/2lb) for each child. When pods have filled out, pick 226g (1/2lb) for each person.

French: 5 rows, 30cm (1ft) apart, seeds 25cm (10in) apart. This should also give you a surplus for freezing. Allow 170-226g (6-8oz) per person.

Runner: 1 double row, 60cm (2ft) apart, when grown up a support. On the flat, 4 single rows, 60cm (2ft) apart. Seeds 30cm (1ft) apart. Pick 226g (1/2lb) per person.

Beetroot
1 row for summer salads gives 30-40 small beet; 2 rows, 30cm (1ft) apart, for autumn and winter use.

[27] © David Charles from the book "Organic Gardening" by Roy Lacey, ISBN 0-7153-9175-5.

Broccoli, Purple Sprouting
1 row of six plants. Pick without any large leaves, allowing 170gm (60z) per person.

Brussels Sprouts
6 rows, 45cm (18in) apart, plants about 60cm (2ft) apart, but distance varies according to variety. Aim for 20 early, 20 mid-season and 20 late maturing plants. Pick 26g (1/2lb) per person.

Cabbages
Spring: 3 rows, 45cm (18in) apart each way, some to eat as spring greens, allowing others to heart up. Allow 226gm (1/2lb) per person of greens.

Summer, autumn: 2-3 rows 9giving 20-25 heads, depending upon size), 45cm (18in) apart each way on average. For the family of five you will need a cabbage trimmed of coarse outer leaves weighing 1.10 - 1.36kg (2.5 - 3lb).

Winter: 3 rows, plants 45cm (18in) apart each way to give about 30 heads, Each with a finished weight of 1.36 - 1.8kg (3 - 4lb).

Carrots
Early: 2 rows, 15cm (6in) apart, do not thin. Pull 6-9 carrots per person for earliest feeds, 4-5 when larger.

Maincrop: 2 rows, 20cm (8in) apart. Allow 170g (6oz) per person.

Cauliflowers
Spring and summer - 15 heads; autumn - 12 heads; winter - 12 heads. Winter 75cm (2.5ft) apart each way, others 60cm (2ft) apart each way, except for mini-caulis. A 1kg (2lb) head with leaves trimmed will serve five people.

Celery
1 row, 1m (3ft) wide with about 25 plants staggered and 15 - 22cm (6-9in) apart. For braising you will need 3 heads for six people.

Courgettes
6 plants, 1m (3ft) apart each way. Allow 226g (1/2lb) per person.

Kale
3 rows, 60cm (2ft) apart each way. Pick while young allowing 171g (6oz) per person.

Leeks
3 rows, 30cm (1ft) apart, 25cm (10in) between plants. Allow one well grown leek per person.

Lettuce
Cos or cabbage types, 2 rows 30cm (1ft) apart, sown half a row at a time for succession, thinned 15-22cm (6-9in) apart. Depending upon variety. Pick as required for salad or sandwich use.

Marrows
4 plants of bush type, 1m (3ft) apart. A 1.3kg (3lb) marrow is sufficient for the family.

Onions
Spring: 1row, sown a third at a time for succession.

Maincrop: 450g (1lb) of onion sets consists of about 100 bulbs. Place 10cm (4in) apart in rows 30cm (1ft) apart to give a finished crop totalling 22.7-36.3kg (50-80lb) which will see you through the winter and spring.

Parsnips
2 rows, 20cm (8in) apart 7.5cm (3in) between plants. Allow about 340g (3/4lb) of untrimmed roots per person when used as a main vegetable.

Peas
6 rows, (3 early, 3 maincrop), 1m (3ft) between rows, 7.5cm (3in) between seeds. This should give a decent surplus for freezing. For early varieties picked young allow 450g (1lb) of pods per adult. For maincrop, picked with full pods, allow 280g (10oz) per person.

Potatoes
3kg (6.6lb) of seed potatoes for every 3 rows produces 22.7-31.7kg (50-70lb) of earlies and up to 45kg (100) of second early and maincrop varieties, but a lot depends upon the variety and the season. Allow 170gm (6oz) of earlies, and 226g (1/2lb) maincrop (unpeeled) per person.

Radishes
2 rows, sown thinly, half a row at a time for succession, 15cm (6in) between rows.

Shallots
Pickling, 1 row, bulbs 30cm (1ft) apart. Cooking, 2 rows, bulbs 30cm (1ft) apart each way.

Spinach
Summer, 3 rows, 30cm (1ft) between plants, 37.5cm (15in) between rows. Winter, 2 rows, spacing as for summer. Allow about 141g (5oz) of leaves picked young with a minimum of stalk.

Swedes
2 rows, seeds 15cm (6in) apart, 45cm (18in) between rows. Allow 280g (10oz) of untrimmed roots per person when used as a main vegetable.

Tomatoes
Outdoor bush type, 6 plants, 1m (3ft) apart each way. Outdoor standard type, 6 plants, 45cm (18in) apart in row.

Turnips
Summer, 2 rows, 25cm (10in) apart, seedlings thinned to 10cm (4in) apart. Winter, 2 rows, 30cm (1ft) apart, seedlings thinned to 15cm (6in) apart. Allow 226-280g (8-10oz) of untrimmed root per person.

Germination Conditions - Soil Temperature for Vegetable Seed

CROP	Minimum, °F.	Optimum Range, °F.	Optimum, °F.	Maximum, °F.
Asparagus	50	60-85	75	95
Bean	60	60-85	80	95
Bean, Lima	60	65-85	85	85
Beet	40	50-85	85	95
Cabbage	40	45-95	85	100
Carrot	40	45-85	80	95
Cauliflower	40	45-85	80	100
Celery	40	60-70	70*	85*
Chard, Swiss	40	50-85	85	95
Corn	50	60-95	95	105
Cucumber	60	60-95	95	105
Eggplant	60	75-90	85	95
Lettuce	35	40-80	75	85
Muskmelon	60	75-95	90	100
Okra	60	70-95	95	105
Onion	35	50-95	75	95
Parsley	40	50-85	75	90
Parsnip	35	50-70	65	85
Pea	40	40-75	75	85
Pepper	60	65-95	85	95
Pumpkin	60	70-90	95	100
Radish	40	45-90	85	95
Spinach	35	45-75	70	85
Squash	60	70-95	95	100
Tomato	50	60-85	85	95
Turnip	40	60-105	85	105

Watermelon	60	70-95	95	105

*Daily fluctuation to 60 degrees or lower at night is essential.

From James Edward Knott, Handbook for Vegetable Growers,
John Wiley& Sons, Inc., New York, 1957, p. 8.

Secondary source: "How to Grow More Vegetables than you ever thought possible on less land than you can imagine". John Jeavons, Ten Speed Press, California.

Land Output and Yields

GENERAL RELATIONSHIPS

There are great differences in the amount of arable land per person in the various regions of the world. The greatest amount of arable land per capita is in Oceania; the least is in China. No direct relationship exists between the amount of arable land per capita and the level of income; Europe has almost as little arable land per capita as Asia and less than Africa; Japan and The Netherlands have very limited amounts of arable land per capita.

The relationship between land, population, and farm production is a complex one. In traditional agriculture, where methods of production have changed little over a long period of time, production is largely determined by the quality and quantity of land available and the number of people working on the land. Until the early years of the 20th century, most of the world's increase in crop production came either from an increase in land under cultivation or from an increase in the amount of labour used per unit of land. This generally involved a shift to crops that would yield more per unit of land and required more labour for their cultivation. Wheat, rye, and millet require less labour per unit of land and per unit of food output than do rice, potatoes, or corn (maize), but generally the latter yield more food per unit of land. Thus, as population density increased, the latter groups of crops tended to be substituted for the former. This did not hold true in Europe, where wheat, rye, and millet expanded at the expense of pasture land; but these crops yielded more food per acre than did the livestock that they displaced.

As agriculture becomes modernized, its dependence upon land as well as upon human labour decreases. Animal power and machinery are substituted for human labour; mechanical power then replaces animal power. The substitution of mechanical power for animal power also reduces the need for land. The increased use of fertilizer as modernization occurs also acts as a substitute for both land and labour; the same is true of herbicides and insecticides. By making it possible to produce more per unit of land and per hour of work, less land and labour are required for a given amount of output.

Crop yields have increased dramatically since 1950, with a faster rate of growth in the developing than in the developed countries. Most of this increased output has been due to gains in yields rather than to the expansion of cultivated land.

In Europe as well as in North and Central America, the total area under crops has declined; in South America it has increased by more than one-half and in Asia by more than one-third. The large increase in Oceania was due to immigration. The large decrease in Africa was due to a succession of droughts from the 1970s on.

Grain yields in the developed regions of the world have increased consistently over the past several decades. In the rest of the world the pre-World War II yields were not achieved again until the mid-1950s. The increases in grain production were more than twice as high in the developing as in the developed countries.

Food production and total agricultural production exhibit nearly identical trends, and changes in food production can be taken therefore as indicative of changes in total agricultural production. Food supplies per capita in developing countries have increased at nearly the same rate as in developed countries, indicating a narrowing gap between food supplies and population growth in the developing countries.

Policies of the EEC.

The EEC has established a common agricultural policy (CAP) for the Common Market countries. The CAP, worked out for each major farm commodity, was originally designed to create free trade for that commodity within the community. Special subsidies by the individual countries, and other national farm programs, were to be eliminated to prevent competitive advantages. The first of the regulations implementing the CAP were enacted in 1962 and applied to grain (except rice), poultry, eggs, live hogs and whole hog carcasses, fruit and vegetables, and wine. Similar programs were developed later for beef, dairy products, sugar, rice, and fats and oils.

The most important features of the CAP mechanism are the target prices, the threshold prices, the support or intervention prices, the variable levies on imports to make up the difference between landed prices and threshold prices, and export subsidies or refunds equal to the difference between market prices in the EEC and in the importing country. For most CAP commodities the primary device for achieving target prices is the variable import levy. This levy, which fluctuates with the import cost of a commodity, keeps the domestic price at or near the target price if the commodity is imported. When EEC production of a commodity exceeds EEC consumption, the authorities may purchase the commodity for storage, pay to have it processed for another use (*e.g.,* wheat may be denatured and sold as a feed grain), or subsidize its export to countries outside the EEC. With these techniques the EEC has been able to maintain farm prices at levels substantially higher than those prevailing in the United States and Canada.

Throughout the 1960s the EEC did nothing to limit or control the production of agricultural products. When large stocks of butter and dry skim milk accumulated, and as the costs of maintaining dairy product prices and subsidizing wheat exports mounted, consideration was given to reducing production. A payments program to induce shifts from dairy to beef production was inaugurated, and there was talk of reducing the area cultivated for grain. Output limitation has been made difficult, however, by the significant differences in circumstances among the farmers in the various EEC countries.

Calculation of Costs and Returns of Production

Introduction

Northeastern farmers produce literally hundreds of products ranging from traditional crop and livestock products to vegetables, nursery products, greenhouse products. For the purposes of this study, it was decided that the research would focus on key products for which researchers, agents, policymakers, and farmers typically need information.

Production costs of farm products vary considerably, from farm to farm and season to season. The variations are based on the unique character of each operation and the uncertainty of factors beyond the control of the farm operator. The source of some of the differences can be found in several key input categories, such as: (1) machinery costs which can vary because of the differences in age, size, and usage of equipment; (2) irrigation costs which are subject to variations in rainfall, temperature, and irrigation systems; (3) fertilizer, seed, and chemical costs which will vary depending on quantities used and prices paid; and (4) labor costs which are dependent on prevailing wage rates, working conditions, and the efficiency of individual workers. Standardized values have been used in the estimation of production costs, assuming typical practices under average conditions on commercial farms. Thus, the budgets included in this study are intended to be used as a guide to help producers develop costs of production budgets for their particular operation.

Crop production costs include expenses for materials used in production such fertilizers, chemicals, seeds or plants, and fuel; costs of land, labor, machinery and management; and irrigation and marketing costs where applicable. Livestock production costs include expenses for replacement stock, feed, utilities, insurance, medicines and marketing; cost of labor and management; and cost of land and buildings. In addition, interest on operating capital was charged on variable costs in all cases. Since standardized values have been used in the development of the budgets, they are able to provide the type of information needed for management decisions and for comparing relative profits and cost structures between enterprises. The detailed methodology for the estimation of production costs and net returns is discussed below.

A. CROP BUDGETS

A.1. Receipts per Acre

Receipts per acre were determined by multiplying the average yield by the season adjusted price for each crop. It should be noted that the yields represent the best estimate of the marketable yields expected by a commercial grower. The 1996 season adjusted prices and in some cases, weighted average prices, were used.

A.2. Costs per Acre

A.2.1. Materials and Related Services

Cost of materials and related services make up a major component of variable costs involved in the farming operation. The items included are: custom work such as lime application and grain drying; chemical inputs such as fertilizer, herbicides, fungicides, and insecticides; seeds or transplants; fuel; marketing; and packing containers for fruits and vegetables. Chemical usage is based on conventional practices. Given the great interest in reducing chemical inputs in agricultural production, the chemical input section is itemized in detail, enabling the grower to estimate changes in net profits based on changes in chemical use. Input prices for 1996 reflect grower rates, which are the discounted prices applicable to large volume purchases.

A.2.2. Labor

For a more accurate estimation of labor costs, labor was divided into three categories: operator labor, regular hired labor, and seasonal hired labor. Operator labor is used primarily for operating machines and for tasks which require a high level of skill. This type of labor is generally provided by the owner or farm family members. Regular hired labor is somewhat less skilled and used primarily for the performance of general farm operations such as equipment operation, pruning, etc. Seasonal hired labor is used primarily for planting, weeding, harvesting, and packing of products. The amount of operator, regular hired, and seasonal hired labor required for each crop depends on the number and frequency of tasks, the overall size of the operation, and whether harvesting is accomplished by hand or machine.

Labor wage rates for 1996 are based on the New Jersey Agricultural Statistics Service average cash wage rates paid in January and July. In addition, mandatory state and federal benefits such as social security, workers compensation, and unemployment insurance were also included. The estimated wage rates and benefits are as follows: Operator: $12.32 + 17.5% in benefits or $14.48/hour; Regular hired labor: $8.62 + 17.5% in benefits or $10.13/hour; Seasonal hired labor: $6.90 + 11.95% in benefits or $7.24/hour. These wage rates were applied to all the budgets to allow for consistency, regardless of the state of origin.

A.2.3. Machinery and Equipment

Machinery and equipment costs consist of overhead costs and operating costs. The estimates of the overhead or fixed costs of machinery and equipment were based on the replacement values of the machines, and include depreciation, interest, and insurance. The operating costs include repair and maintenance costs, as well as fuel and oil costs of self propelled machinery. The operating costs of machinery are a component of variable costs.

A.2.4. Irrigation

Irrigation is essential for producing quality fresh fruits and vegetables in the Northeast.. Therefore, costs of installing and operating an irrigation system are included in the budgets. The cost of irrigation is accounted for differently for fruits than for vegetables. The fruits included in this study are perennial crops and the budgets were developed for the various growing cycles. The cost of installing the irrigation system is accounted for in the planting year and operating costs of the system are included in each subsequent year. For apples and peaches, custom installation of a drip irrigation system for 272 and 141 trees respectively, was estimated by an irrigation system installation firm. The cost for apples is $800 per acre, and the cost for peaches is $700 per acre. It is anticipated that the useful life of the system is the same as the life of the orchard (about 20 years). For years one through twenty, for both apples and peaches, the annual operating costs per acre including energy and maintenance costs, are estimated to be $250.

The cost of a custom installed solid-set irrigation system for blueberry production is estimated to be $2,000 per acre. It is anticipated that the system will last the life of the plantings (about 20 years). The annual operating costs of the system including energy and maintenance costs are estimated to be $200 per acre. The cost of installing and operating an irrigation system for cranberries which is used during the period when the bogs are not flooded, is estimated to be $2,000 and $200, respectively. For raspberries, the cost of installing a drip irrigation system is estimated to be $530 per acre, with operating costs estimated at $120 per acre. A drip irrigation system for strawberries is estimated to cost $810 for installation and $100 for operating costs per acre.

Overhead and drip are the two types of irrigation systems most commonly used in vegetable production. Cabbage, cucumbers, lettuce, pumpkins, snap beans, sweet corn, and processing tomatoes are typically irrigated with an overhead sprinkler system. For these crops, costs per acre including fixed and operating expenses are estimated at $192. Bell peppers and fresh market tomatoes typically utilize drip irrigation. Costs per acre, including fixed and operating expenses, are estimated at $300.

A.2.5. Land

Cost of land for producing field crops was estimated by using the 1996 agricultural value of cropland which was reported to be $661 per acre by the New Jersey Department of Agriculture and the State Farmland Evaluation Advisory Committee. Using an interest rate of 7.5%, the annual cost of land is estimated at $49.58. Additional information obtained from farmers and county agents, indicated that rental rates for cropland in the state are about $50. Given the consistency of the two figures, the annual cost of land for field crops is assumed to be $50 per acre.

For higher value crops such as fruits and vegetables, a cost of $100 per acre is used based on the recommendations of Cooperative Extension personnel and selected growers. For cranberries, a cost of $250 per acre is used. This figure is justified by the high value of the crop, the stringent regulations regarding new bog creation, and the limited supply of bog acreage. In all cases, land cost was assumed to be inclusive of property taxes.

As with labor wage rates, the cost of land was kept consistent among the budgets, regardless of the state of origin. This was done to allow for a more accurate comparison of production costs among the various crops and production methods.

A.2.6. Interest on Operating Capital

It is a common practice among farmers to incur short term loans to pay for supplies, labor, and purchased inputs. To account for this, interest on operating capital is included as a cost of production. Interest on operating capital is charged on total variable growing costs at a rate of 10 percent per annum for half of the growing period which was assumed to be seven months. Interest on harvesting and marketing costs is calculated for a period of one month only. For the non-bearing years of perennial crops such as apples, peaches, blueberries and cranberries, interest is calculated for the full year. Selling charges for fruits and vegetables are not included in the calculation since they are deducted from revenues at the time of sale. For livestock, interest on operating capital was calculated for a period of one month only, due to the regular flow of revenue from sales.

A.2.7. Allocation of Pre-production Costs

The productive years of perennial crops are generally preceded by a non-productive period when development costs for land preparation, plantings, irrigation installation, and fencing are accrued without generating any revenue. These accumulated development costs of the pre-production period are typically allocated over the subsequent producing years. The pre-production costs for apples, peaches, blueberries, cranberries and raspberries were allocated over 17 productive years and alfalfa-hay and strawberry pre-production costs were allocated over four productive years by using the cost recovery method with an interest rate of 8 percent (See Appendix Tables A1 - A6).

Management Fee

In addition to providing labor, owners also perform managerial functions on the farm. Therefore, in addition to the operator's labor cost, a management fee is also included as a cost of production. A management fee is charged at the rate of 7 percent of total production costs, excluding the cost of land and packing boxes (USDA, 1979; Dhillon and Latimer, 1986).

Marketing Costs and Selling Charges

Marketing costs, where applicable, have been included as a cost of production. These costs can include items such as picking and packing boxes, packaging materials, transportation and selling charges. An important component of the marketing process is the transaction method used to sell the product. A significant portion of farmers in the Northeast sell their products through a third party, typically an auction or a broker, for which a selling charge is assessed in return for services. Vegetable auctions usually charge a rate of 3% of gross sales, thus this rate was used as the basis for selling charges on all vegetable budgets. A rate of 6% of gross sales is typically charged at fruit auctions and this rate was used for the apple, peach, strawberry, and raspberry budgets. The majority of blueberries are sold through a broker system, with an average selling charge of 9% of gross sales. No selling charges were included in the cranberry budget since the berries are usually contracted to a processor, such as Ocean Spray.

Livestock Budgets

Cost of production budgets for five important livestock enterprises, namely, dairy cow, poultry (egg layers), dairy beef, spring lambs, and goats are included in this study. The dairy cow budget is based on a cow producing 19,000 pounds of milk plus the cost of raising a replacement. Receipts from the enterprise include milk sales and a percentage of cull cow, heifer and bull calf sales. The budget for dairy beef steer is based on the assumption that the calves are purchased at 100 pounds and are sold at a weight of 1,300 pounds. Variable costs of the enterprise include costs of purchased and home grown feed; bedding, veterinary, fuel, utilities and miscellaneous expenses; marketing costs; labor costs; and repair and maintenance expenses.

The poultry budget is based on a 108,864 bird cage operation which consists of four decks of cages laid out in six rows with nine birds per cage. Production receipts are generated by the sale of six grades of eggs (jumbo, extra large, large, medium, small, and undergrades) as well as the sale of fowl. Among the cost items, feed represents the largest proportion of expenditures, accounting for over half of the costs.

There are three budgets for dairy goats based on the level of milk production - 1,500 lbs., 1,800 lbs., and 2,100 lbs. In all cases, the budgets are based on a 100 doe facility using artificial insemination, with does producing an average of two kids per year. Revenues from dairy goat production are generated from milk sales and the sale of culled does and male kids.

The spring lamb budget includes feed costs based on lambs and replacements fed to 110 pounds. It is estimated that 1.65 lambs are marketed per ewe with additional revenues coming from the sale of culled ewes, rams, as well as wool and hides.

ICM Budget Information

The integrated crop management budgets are based on the sustainable practices described in Part II and were provided by Northeast Farm Management Committee members affiliated with The Pennsylvania State University Cooperative Extension and the University of Massachusetts Cooperative Extension. For the purposes of this study, the budgets were adjusted to reflect a standard price for chemicals, seeds, transplants, labor, land, and irrigation among all of the budgets so that comparisons can be more accurately made between enterprises and cropping systems.

Cost of support services for integrated crop management such as scouting fees and soil tests were not included in the budgets. In many states, these services are provided by the cooperative extension for a minimal fee and charges vary by enterprise. The following are estimated scouting costs for New Jersey farms. For field crops, scouting fees are charged by the acre and cost about $8 an acre. Scouting fees for vegetables vary by crop - for example, some typical charges are: $9/ acre for sweet corn, $30/acre for tomatoes, $20/acre for peppers, $20/acre for cole crops <20, $10/acre for cole crops >20 acres, $5/acre for potatoes, $5/acre for beans, and $5/acre for cucumbers. Fees include twice weekly visits and posting of field and trap data with thresholds when applicable. Blacklight Trap programs are also available at a cost of $325 per farm. Scouting fees for tree fruits are $10-$12/acre for peaches and $14/acre for apples, with a $300 minimum per farm. Soil tests with micro-nutrient levels cost about $8-$10 per field.

Organic Budget Information

Costs of production for the organic budgets were based on information provided by the Rodale Insitute for field crops, University of Vermont for livestock, and the University of California, Davis for apples and vegetables (due to lack of information in the northeast). All budgets were adjusted to reflect input costs in the northeast including costs of manure, organic chemicals, seeds, transplants, labor, machinery, land, and irrigation. No information is provided on yield quantities or prices in the budgets due to lack of reliable data.

The organic budgets in this study reflect the practices and costs associated with an intensive organic production system. The farms represented are assumed to be certified as organic. Commodities that are produced organically can often be sold for a premium price over conventionally grown products (about 15%-20% higher). However, the supply of organic products, market competition, and consumer demand can affect grower returns. A description of some general assumptions upon which the vegetable and apple budgets were based is provided in the following discussion.

For the organic vegetable budgets, production costs were based on the assumption that crops are planted on 40 inch beds. Seed and transplant costs are within a range of costs for different open-pollinated and hybrid vegetable cultivars. Varietal planting decisions should ultimately be based on the crop’s compatibility to the climatic region, the disease resistance capability, yield potential, overall quality at harvest, and the cultivar’s marketability. To manage soil tilth, fertility, and nutrient levels, some soil amendments such as compost and manure are applied to production lands.

In this study, disease incidence and pest damage are assumed to be low. However, this may vary on a year to year basis depending on pest populations and management techniques. Weed populations are reduced through a variety of techniques including mechanical cultivation, hand and flame weeding. Most harvest operations are performed by the grower with some contract labor, and reflect hand harvest and field or shed packing.

The organic apple budget is based on an orchard size of 40 acres. Apple varieties are not specified in this study. Factors affecting varietal selection include adaptability to climatic region, time to maturity and marketability. Trees are planted on a 12' x 18' spacing with 202 trees per acre. A winter annual cover crop is sown each year in the fall. The cover crop is not irrigated, but is dependent on moisture in the soil profile and rains for germination and growth. In the spring, the cover crop is incorporated into the soil. Following this, composted manure is applied and disced into the soil. Throughout the remainder of the spring and summer, orchard centers are disced periodically to control weeds. Hand weeding is used to control any vegetative growth in the tree rows. Not other means of weed control are used in this report.

In general, pest control products used by organic growers are not as effective as synthetic pesticides for immediate or acute problems. The cost for some organically acceptable pest control methods may be prohibitive for many growers. Therefore, orchard sanitation, pest identification, monitoring and prevention are essential elements of successful organic apple production. Also, the timing of material applications is critical for effective insect and disease control in apples.

Apples are hand thinned as opposed to chemical thinning in the conventional and ICM budgets. The number of thinnings depends on the variety, seasonal conditions, and targeted market. Growers often thin higher value apples more than one time each year in order to produce consumer-preferred large size fruit. Harvesting is performed by the grower and is done by hand. This study assumes that harvest takes place in October. The assumed fresh market yield for organic apples is 375 boxes per acre. Boxes weigh 40 pounds and are tray packed. Yields may vary widely depending on such factors as planting density, variety, orchard age, production location, and seasonal growing conditions.

Data – Payments

ARABLE AREA PAYMENTS
FOR NI GROWERS FOR THE 1997/98 MARKETING YEAR

£/ha

	Cereals	**Oilseeds**	**Pulses**	**Set-aside**
NI non-LFA	227.98	431.09	329.30	288.77
NI LFA	219.68	431.09	317.31	278.26

prepared for the www - 31 July 1997

Greenmount College of Agriculture and Horticulture

Data – Companion Growing

Canberra Organic Growers' Society Inc.

Companion Planting

Plant	Good Companions	Bad Companions
Asparagus	Tomato, Basil, Parsley	Potatoes
Beans	Carrots, Cabbage, Cucumber, Cauliflower	Leeks, Chives, Garlic, Onions
Broad Beans	Potatoes, Lettuce	Fennel
Bush Beans	Strawberries, Grapes	Garlic, Onions
Dwarf Beans	Beetroot, Kohlrabi	
Beetroot	Kohlrabi, Dwarf Beans, Onions, Chives	Runner/Climbing Beans, Lettuce, Silverbeet, Cabbage, Leaf Mustard
Broccoli	Dill, Celery, Chamomile, Sage, Rosemary	Tomatoes, Strawberries, Oregano
Brussel Sprouts	Potatoes, Sage, Hyssop, Thyme	Strawberries, Rosemary
Cabbage	Beetroot, Potatoes, Beans, Onions, Sage	Tomatoes, Garlic, Strawberries, Celery, Dill, Mint, Thyme, Oregano
Capsicum	Basil	-
Carrots	Leeks, Lettuce, Onions, Peas, Tomatoes	Dill, Parsnip, Chives, Sage, Rosemary, Radish
Cauliflower	Celery, Celeriac, Beans, Oregano	Strawberries, Rue, Peas, Potato, Nasturtium
Celery	Leeks, Beans, Cabbage, Tomatoes	Parsnip, Potato, Wheat
Corn	Melons, Squash, Pumpkins, Cucumbers, Potatoes, Parsnips, Artichokes, Jerusalem Artichokes	-
Cucumber	Beans, Peas, Radish, Celery, Carrots	Potatoes, Sage, Cauliflower, Basil
Chives	Carrots, Tomatoes, Parsley, Parsnips, Fruit Trees	
Eggplant (Aubergine)	Beans, Potato, Marjoram	
Horseradish	Potatoes, Fruit Trees	
Kohlrabi	Beetroot, Onion, Dwarf Beans	Pole Beans, Tomatoes, Cucumber
Leeks	Carrots, Celery, Celeriac, Strawberries	

Lettuce	Strawberries, Cabbage, Carrots, Onions	Parsley, Beans, Beetroot, Parsnip
Nasturtium	Cabbage, Cauliflower, Cucumber	Broccoli, Brussel Sprouts, Potato, Radish, Squash, Zucchini, Fruit Trees
Onions	Cabbage, Carrots, Beetroot, Lettuce	Beans, Peas, Parsnip, Parsley, Leeks
Potato	Beans, Corn, Cabbage, Horseradish	Pumpkin, Squash, Cucumber, Dill, Eggplant, Tomatoes, Raspberries
Peas	Carrot, Corn, Cucumber, Beans, Radish	Onions, Garlic, Shallot
Pumpkin	Sweetcorn, Marjoram	Potato
Radish	Cucumber, Lettuce, Kohlrabi, Melon	Hyssop, Squash, Peas, Nasturtium
Spinach	Broad Beans, Strawberries, Fruit Trees	
Tomato	Asparagus, Basil, Lima Beans, Cabbage	Beetroot, Fennel, Kohlrabi, Broccoli, Brussel Sprouts, Cauliflower, Potato, Rosemary, Carrots, Chives, Dill, Onions, Parsley, Parsnip, Nasturtium
Zucchini	Corn, Marjoram, Nasturtium	

S = Seed sowing
T = Transplant

Notes:

(1) This table is a guide only, please observe the seasonal weather patterns before deciding when to plant, as there will often be distinct differences in summer weather from one year to the next.

(2) Planting times will vary for different varieties of the one vegetable, for example, December plantings of Heading Lettuce should be successful; in February, plantings should be the Butterhead variety.

Sowing and Harvesting Plan - Vegetable and Salad Crops

This chart indicates chief outdoor sowing and planting dates and season of use of common crops. Frame and greenhouse sowings and cultural details of all vegetables and salads, plants and herbs are given in the alphabetical section.

Crop	Sow in Open	Plant Out	When Ready	Available until
ARTICHOKE (Jerusalem)		Feb-Mar	Nov	March
BEAN, Broad Dwarf French	Nov, Feb-May Late April		June July	Aug Sept
Runner	May, June		July	October
Haricot	Early May		Nov	Late Winter
BEET	April-late May		July	March
BROCCOLI	Mar-May	May-June	Oct	May
BRUSSELS SROUTS	Mar-April	May-June	Nov	March
CABBAGE Spring Autmun	 July-Aug April	 Oct June	 Feb Oct	 May January
CARROT	Mar-April		July	April
CAULIFLOWE R	Early April	May-June	July	October
CELERY	April	June-July	Dec	April
CRESS	Mar-Sept			
KALE	Early April	June-July	Dec	April
LEEK	March	July	Oct	April
LETTUCE	Mar-Aug			
MARROW	May	May-June	Aug	November
ONION	Mar Aug	May-June	Sept March	May June
PARSLEY	Mar-July		June-Oct	All the year
PEA, Early Maincrop	Feb-Mar Mar-April		June July	July August
POTATO, Early Maincrop	Mar-April April-mid May		July Late Sept	September May
RADISH	Mar-Sept			
RHUBARB		March	April	July
SAVOY	Mar-April-May	May-July	Aug	March
SHALLOT		Jan-Feb	July	March
SPINACH	Feb-Aug		May	September
SWEDE	May-July		Oct	March

TOMATO	In heat	Late May	July	October
TURNIP	Aug		Oct	December

Vegetable Crop Irrigation

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Vegetables are 80 to 95 percent water. Because they contain so much water, their yield and quality suffer very quickly from drought. When vegetables are sold, a "sack of water" with a small amount of flavoring and some vitamins is being sold. Thus, for good yields and high quality, irrigation is essential to the production of most vegetables. If water shortages occur early in the crop's development, maturity may be delayed and yields are often reduced. If a moisture shortage occurs later in the growing season, quality is often reduced even though total yields are not affected. Most vegetables are rather shallow rooted and even short periods of two to three days of stress can hurt marketable yield. Irrigation is likely to increase size and weight of individual fruit and to prevent defects such as toughness, strong flavor, poor tipfill and podfill, cracking, blossom-end rot and misshapen fruit. On the other hand, it reduces soluble solids in muskmelons and capsaicin in hot peppers if applied during fruit development.

Growers often wait too long to begin irrigating, thinking, "It will rain tomorrow." This often results in severe stress for the portion of the field that dries out first or receives irrigation last. Another common problem is trying to stretch the acreage that can reasonably be covered by available equipment. Both of these practices result in part or all of the field being in water stress. It is best that a good job be done on some of the acreage rather than a "half-way job" being done on all the acreage.

Drought stress can begin in as little as three days after a 1-inch rain or irrigation in such crops as tomatoes in soils like those in the Piedmont of North Carolina. Thus, frequent irrigation is necessary for maximum yield. Soil moisture requirements differ with the crop and stage of crop development. Soil moisture availability varies with the amount of water in the soil and the type of soil. Soil type is very important in planning for and using an irrigation system. Various vegetable crops are listed in Table 1 as to the critical stage and irrigation needs.

Up to 1.5 inches of water is needed each week during hot periods to keep vegetable crops that have a plant spread 12 inches or more. This need decreases to .75 inches per week during cooler seasons.

Droplet size and irrigation rate are also very important in vegetable crops. Large droplets resulting from low pressure at the sprinkler head can cause damage to young vegetable plants and contribute to crusting when soil dries. Irrigation rate is also important in sandy soils that absorb water more readily than clay soils. However, clay soils have a greater percent of the water available. Irrigation rate will depend on soil type but application rates should not exceed 0.40 inch per hour for sandy soils, 0.30 inch per hour for loamy soils or 0.20 inch per hour for clay soils. High application rates will result in irrigation water running off the field, contributing to erosion and fertilizer runoff.

Improving stands - Most vegetables have small seed which are planted 0.75 inch deep or less. When seeds are planted shallow, the upper layer of soil can dry rapidly, leaving the seed half germinated with not enough soil moisture to complete germination. When this happens, no stand or at best an incomplete stand will result. An irrigation of 0.50 to 0.75 inches immediately after planting should be applied to settle the soil and to start seeds germinating. For larger seeded crops, irrigation a few days prior to seeding is desired. If seeds are slow to come up due to cool temperatures or slow germination, then irrigations of 0.75 to 1 inch per acre should be applied as needed. This should be done to keep the area around the seed moist until seedlings emerge. Irrigation is a valuable tool in getting a good, uniform stand which insure high yields. Good uniform stands also mean uniform harvest dates and more efficiency of production.

Vegetable transplants also require good soil moisture. A light irrigation of 0.50 to 0.75 inch per acre will help establishment by providing a ready supply of water to young broken roots.

Irrigation at planting time can also reduce soil crusting and hasten seedling emergence. If 0.50 to 0.75 inch of irrigation is slowly applied, either with low rates or by turning the irrigation system off long enough to allow water to soak in, crusting can be reduced and stand will be improved.

Product development and fruit set - Wide fluctuation in soil moisture injure fruit crop vegetable like tomatoes and peppers (Table 1). These fruits contain large amounts of water and depend on this water for expansion and growth. When soil moisture is allowed to drop below the proper level, the fruit does not expand to produce maximum size before it ripens, thus reducing yield. If moisture is allowed to fluctuate too much, blossom end rot can occur and fruit is no longer useable.

If moisture fluctuation occurs during the fruit expansion stage, fruit cracking will occur. Fruit cracking usually occurs when inadequate water has been applied and then heavy rains bring too much water (Table 1). The best way to prevent fruit cracking is a steady moisture supply. Second growth or knobs in potatoes are also caused by soil moisture fluctuations.

Rooting depth - It is important that the soil profile be filled with water at each irrigation. Frequent light irrigations result in shallow root systems. Shallow root systems result in plants being stressed even in short periods of water deficit, not Table 1 for crop specifics. On the other hand, excessive irrigation leaves crops vulnerable to leaching from rain or irrigation.

The rooting depth of various vegetables is listed in Table 1. It is important that shallow rooted crops receive more frequent irrigations.

Preferred minimum soil moisture - Soil moisture is measured with a *tensiometer* or *soil block*. The former is preferred for sandy soils and the latter for clays and loams. Tensiometers report soil moisture in centibars (.001 bar), suggested soil tensions for various vegetables are reported in Table 1. Soil blocks report available soil moisture (ASM) and Table 1 suggests minimum levels for most vegetables.

Amount and timing - Irrigation amounts and time between irrigations are critical to efficient irrigation practices. Some suggestions for amount and timing of irrigations are presented in Table 1.

Critical moisture periods - Critical periods of irrigation needs can best be defined as that time when soil moisture stress can most reduce yield in an otherwise healthy crop (Table 1). This is not to say that it is the only time in the life of the crop that moisture stress reduces yield. It is, however, the time when stress has the greatest effect.

Irrigation method - Vegetable crops differ in which method of irrigation can be used economically in their production (Table 1).

Drought tolerance - Drought tolerance is an indication of a crops ability to withstand short periods of drought without significantly reducing yield. We have classified vegetable for drought tolerance in Table 1.

Defects from stress - Most vegetables respond to water deficit with reduced yield and quality. However, most crops also express this stress with growth abnormalities, these are listed in Table 1.

Table 1. Vegetable Irrigation Needs, Critical Moisture Periods, Drought Tolerance, Rooting Depth, and Concerns.

	Preferred Minimum Soil Mosture				
Crop	Bars	ASM[1]	Amount/inches in "x" days	Irrigation Critical Moisture Period	Preferred Irrigation Method[2]
Asparagus	-.70	40%	1/20	Crown set and transplanting	a,b
Beans, dry	-.45	50%	1/7	Flowering	a
Beans, lima	-.45	50%	1/7	Flowering	a,b
Beans, pole	-.34	60%	1/5	Flowering	a
Beans, snap	-.45	50%	1/7	Flowering	a
Beans, soy (edible)	-.70	40%	1/14	Flowering	a,b
Beet	-2.00	20%	1/14	Root expansion	a,b
Broccoli	-.25	70%	1/5	Head development	a,b,c
Brussels sprout	-.25	70%	1/5	Sprout formation	a,b,c
Cabbage	-.34	60%	1/10	Head development	a,b
Carrot	-.45	50%	1/21	Seed germination, root expansion	a,b
Cantaloupe	-.34	60%	1/10	Flowering and fruit development	a,b
Cauliflower	-.34	60%	1/5	Head development	a,b,c
Celery	-.25	70%	1/5	Continuous	a,b,c,d
Chinese cabbage	-.25	70%	1/5	Continuous	a,c
Collards	-.45	50%	1/14	Continuous	a,b,c
Corn, sweet	-.45	50%	1/14	Silking	a,b
Cucumber, pickles	-.45	50%	1/7	Flowering and fruiting	a,b,c
Cucumber, slicer	-.45	50%	1/7	Flowering and fruiting	a,b,c
Eggplant	-.45	50%	1/7	Flowering and fruiting	a,b,c
Greens (turnip, mustard, kale)	-.25	70%	1/7	Continuous	a,b
Leek	-.25	70%	1/5	Continuous	a,b
Lettuce (head, Bibb, leaf, cos)	-.34	60%	1/7	Head expansion	a,b
New Zealand Spinach	-.25	70%	1/5	Continuous	a,b,d
Okra	-.70	40%	1/14	Flowering	a,c

Onion	-.25	70%	1/7	Bulbing and bulb expansion	a,b
Parsnip	-.70	40%	1/14	Root expansion	a,b
Peas, green	-.70	40%	1/7	Flowering	a
Peas, Southern	-.70	40%	1/14	Flowering and pod swelling	a,b
Peppers	-.45	50%	1/7	Transplanting flower up to 1/2" fruit	a,b,c
Potato, Irish	-.35	70%	1/7	After flowering	a,b
Pumpkin	-.70	40%	1/14	Fruiting	a,b
Radish	-.25	70%	1/5	Continuous	a
Rhubarb	-2.00	20%	1/21	Leaf emergence	a,b
Rutabagas	-.45	50%	1/14	Root expansion	a,b
Squash, summer	-.25	70%	1/5	Fruit sizing	a,c
Squash, winter	-.70	40%	1/10	Fruit sizing	a,b
Sweetpotato	-2.00	20%	1/21	Fruit and last 40 days	a,b
Tomato, staked	-.45	50%	1/5	Fruit expansion	a,c
Tomato, ground	-.45	50%	1/7	Fruit expansion	a,b
Tomato, processing	-.45	50%	1/7	Fruit expansion	a,b
Turnip	-.45	50%	1/10	Root expansion	a,b
Watermelon	-2.00	40%	1/21	Fruit expansion	a,b,c

Table 1, Part 2. Vegetable Irrigation Needs, Critical Moisture Periods, Drought Tolerance, Rooting Depth, and Concerns.

Crop	Drought Tolerance[3]	Rooting Depth[4]	Defects Caused by Water Deficit	Comments
Asparagus	H	D	Shriveling	Will withstand most drought
Beans, dry	M	M	Poor pod fill & small beans	No irrigation after pods begin to dry
Beans, lima	L-M	D	Poor pod fill & small beans	Cooling irrigation can increase yield
Beans, pole	L-M	M	Poor pod fill & pithy pods	Steady moisture supply is necessary during flowering
Beans, snap	L-M	M	Poor pod fill & pithy pod	Irrigation prior to flowering has little benefit
Beans, soy (edible)	M	M	Poor pod fill	Irrigation prior to flowering has little benefit
Beet	M	M	Growth cracks	
Broccoli	L	S	Strong flavor	
Brussels sprout	M	S	Poor sprout production	
Cabbage	M-H	S	Growth cracks	
Carrot	M-H	S-M	Growth cracks, misshapen roots	Avoid droughts during root expansion
Cantaloupe	M	S-M		
Cauliflower	L	S	Ricey curd, buttoning	
Celery	L	S	Small petioles	Moisture deficit can stop growth irreversibly
Chinese cabbage	L	S	Tough leaves	
Collards	M	S	Tough leaves	
Corn, sweet	M-H	S	Poor ear fill	Irrigation prior to silking has little value
Cucumber, pickles	L	S-M	Pointed & cracked fruit	Moisture deficit can drastically reduce yield and quality
Cucumber, slicer	L	S-M	Pointed & cracked fruit	Moisture deficit can drastically reduce yield and quality
Eggplant	M	M	Blossom-end rot, misshapen fruit	
Greens (turnip, mustard, kale)	L	M	Tough leaves	Good continuous moisture essential to good yields

Leek	L-M	S	Thin scale formation	
Lettuce (head, Bibb, leaf, cos)	M-H	D	Tough small leaves	
New Zealand Spinach	L	S	Tough leaves, poor production	Irrigate to keep growth continuous and rapid
Okra	M-H	D	Tough pods	Irrigation can reduce yield
Onion	L	S	Poor size	
Parsnip	H	D		
Peas, green	L	M	Poor pod fill	
Peas, Southern	M	M	Poor pod fill	Plants will recover from drought but yield is reduced
Peppers	M	M	Shriveled pods, blossom-end rot	Irrigate for increased pod size and yield
Potato, Irish	M	S	Second growth & misshapen roots	Irrigate only during extreme drought during root development
Pumpkin	M	D	Blossom-end rot	
Radish	L	S	Pithy roots	Keep soil moisture levels high to promote rapid growth
Rhubarb	M	D	Pithy stems	
Rutabagas	M	M	Tough roots	
Squash, summer	L	M	Pointed & misshapen fruit	Fruit sizingIrrigation can double or triple yields
Squash, winter	M	D		
Sweetpotato	H	D	Small & misshapen roots	
Tomato, trellis	M	D	Blossom & root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Tomato, ground	M	D	Blossom & root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Tomato, processing	M	D	Blossom & root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Turnip	M	M	Woody roots	

Watermelon	MH	D	Blossom end rot	This crop can withstand extreme drought, but there will be some yield reduction

Compost

Compost the Weleda way

by Michael Bate,
Head Gardener
Weleda UK

If there is one thing everybody who works in the Weleda gardens loves doing, it's making compost. It is a wonderful experience, seeing the compost heap grow and then watching the original fresh matter change into a lovely fibrous material that will add to the structure and fertility of the soil.

Spraying the heap with valerian juice.

We use a variety of ingredients: grass cuttings; cut green manures like comfrey, buckwheat, annual lupins and Phacelia tanacetifolia with its mauve flowers that attract hundreds of insects, particularly encouraging those that catch aphids; tincture pressings - what is left after processing the plants we grow for medicines - which are ideal for compost because they are finely chopped; weeds before seeding; cow manure in rough proportion of 1:3 with any green material. Nettles are added: they act to get the heap going, and a seaweed meal can be sprinkled on every so often. But it is essential to add an occasional dusting of lime (kept away from the manure) which acts to balance the acidity of the heap.

We make our heaps up to 12 feet long and 5 feet wide, to a height of 4 feet, adding the different ingredients in layers. The art of making fine compost is to ensure the different elements -earth, water, air and warmth - are properly balanced. The heap should not be too wet, nor too dry, not compacted nor too loose. Biodynamic growers follow Rudolf Steiner's suggestion that the addition of small amounts of 6 preparations greatly enhances the breakdown of the compost and increases the benefits when it is spread on the soil. A small amount of each preparation is placed in the middle of the heap in separate amounts:

* Yarrow flowers (preparation 502) - which aid nitrogen and potassium processes in the soil
* Chamomile flowers (503) - which aid calcium processes and stabilise nitrogen in compost
* Stinging nettle (504) - a sensitiser, to enable compost and soil to attune to the crop grown
* Oak bark (505) - a preventative to combat all plant diseases that are due to too much growth
* Dandelion flowers (506) - which act to sensitise plants to the surrounding environment
* Juice from pressed valerian flowers (5 07) which regulates phosphorus and temperature processes, and surrounds the heap with a protective blanket of warmth, is added to the finished heap. A capful of juice is stirred into a couple of gallons of warm water for 10 minutes, then sprayed over the heap.

Finally, the heap is covered with straw or hessian to protect the compost from excessive rain. To ensure thorough decomposition, the heap is remade after three weeks or so, and the outside turned to the inside. The resulting compost is ready within six months. It is best to use only very well-rotted compost/manure for seedlings and growing plants, otherwise there is a risk of fungal problems. The new substances and humus have been formed through a living process of metamorphosis, and bring these life forces with them to re-invigorate the soil and plants.

Preparations approved by the Biodynamic Agriculture Association are available for home gardeners from Paul van Midden, Crannoch Ree, Kingtcausie Estate, Maryculter, Aberdeen A81 2 5FR, telephone 01224 733778.

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Dairy Production

Getting started

In order to produce organic milk the unit must be registered with an organic certification body and the production system adopted must meet the production standards specified. However, each certification body has its own detailed set of standards and it is important to ensure that the system adopted complies with the requirements of the organic body with which you choose to register.

Some of the key aspects of production are given below.

Time scale

It takes a minimum of two years to convert the land to organic status.

Existing cows being converted to organic status must be managed organically for at least 36 weeks except with regard to the feed requirements.

This must be implemented at least 12 weeks before the end of the conversion period.

The minimum conversion period is therefore 2 years and 3 months from the start of conversion until the sale of organic milk.

Feeding

Maximum use should be made of grazing and ideally all of the feed required should be produced organically on the unit. However, where this is not possible up to 20% of the feed for dairy cows, calculated on a daily dry matter basis, may come from non-organic sources. The allowance for dairy youngstock up to calving is 10% non-organic feed.

Forage

Both the pasture grazed and the forage conserved for winter feed will normally be produced on the organic unit itself. At least 60% of the diet should come from organic forage. Red clover, sown with Italian or hybrid ryegrass, can be used to produce bulky silage crops. Molasses, bacterial inoculants and enzyme additives may be used as silage additives.

Concentrates

Where home grown organic cereals are available these can form the basis of the concentrate ration. Purchased organic concentrates are currently in short supply and cost considerably more than conventional feedstuffs. The allowance for non-organic feed facilitates the use of some other feeds, in particular protein sources that may be difficult to produce on the unit. Purchased feed must meet a number of criteria including freedom from genetically modified organisms (GMOs).

Minerals

Mineral supplementation is only permitted where trace element requirements cannot be met by the practices of organic husbandry.

Grassland

Establishment and management of clover-based swards are crucial to the success of organic dairy units. Clover is required to sustain good levels of productivity for both grazing and silage.

Maintaining soil fertility depends on appropriate rotations, alternating silage and grazing ground where possible and the careful allocation of recycled manures and slurry. Artificial fertilisers are not permitted but lime and some natural sources of nutrients can be used. More information is available in the leaflets ‘White clover-based swards on organic units’ and ‘Red clover’.

Brought in manures

Permission may be sought to use manure from another unit. However, the animals from which it is produced must be kept in husbandry systems that satisfy the organic certification body.

Housing

Loose housing, which is well bedded, is preferred for both cows and replacement heifers. Existing cubicles can often be used provided they are of adequate size and that sufficient bedding is provided. The use of slats is restricted to one quarter of the floor area available to the stock.

Animal health

Preventative management is always encouraged but any problems must always be dealt with promptly. The use of homeopathic and herbal remedies is encouraged. If an animal requires treatment a wide variety of veterinary medicines can be used. The withdrawal period must be at least twice the stated withdrawal period with a minimum of 14 days.

Prophylactic use of antibiotics on a herd basis, such as dry cow therapy, is prohibited. Antibiotics and other conventional medicines should only be used to treat disease and illness under the advice of a veterinary surgeon.

Good management practices including teat dipping, and culling cows with high cell counts assist in the control of mastitis.

Vaccination is permitted in herds where there is a known problem on the unit, and which has been agreed with the certification body.

BSE

There have been no cases of BSE in stock which have been born and reared on organic units, although there have been cases in stock which came in as replacements from conventional herds.

In herds where animals have contracted BSE, or where animals have been brought in from other herds in which BSE has occurred within the last six years, all contemporaries, and first generation progeny of all BSE cases, must be removed from the herd by the time it achieves full organic status.

Sources of stock

Existing stock

When a unit is converted to organic production the existing livestock can be retained but can never be sold as organic themselves. However the milk from these cows and their progeny can be sold as organic following the required conversion periods.

Replacements

Although producers are encouraged to rear their own replacements or to buy from other organic units, up to 10% of the breeding herd can be replaced each year from conventional herds which satisfy a number of criteria.

Calves

Calves should preferably be reared on organic whole milk for 9 weeks, or on organic milk replacer, if available. Where surplus calves are not reared and finished on the dairy unit other organic producers may be interested in sourcing stock.

Bulls

Stock bulls can be purchased from conventional units provided they are subsequently managed to organic standards. Hired bulls can be used provided they are managed organically while they are on the unit. The use of AI is permitted.

Selling and buying stock

The sale of organic stock through livestock marts is not generally permitted, with the exception of pedigree stock and rare breeds. Consequently unit to unit trading will become a necessary part of marketing stock. Finished stock should be sold through an outlet approved by an organic certification body in order for the meat to be sold as organic and to avail of premium prices.

Parlour hygiene

Approved sterilants may be used in milking parlours and dairies.

Starting conversion

Conversion planning is a very important aspect of progressing from conventional to organic production. In some cases the whole unit will be converted in one block. In others the conversion may be phased over a number of years, which requires close attention to detail to ensure that milk sold will achieve organic status at the earliest possible date.

Contact for further information

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Market and Marketing

The Market for Organic Produce

Market Facts

The market for organic food is expanding. Every sector is experiencing an increase in demand.

In Ireland the market for organic products is worth £1 to £1.5m representing between 0.03 and 0.05% of the total food market
(Frost and O'Sullivan)

In the UK the organic food market is worth £260m having doubled since 1995 (Mintel)

Over 70% of organic produce sold in the UK is imported

Fruit and vegetables currently represent the bulk of the organic market at 62% (Mintel)

The market for organic food currently represents less than 1% of total retail food sales in the UK

This is expected to rise to around 5% over the next 4 to 5 years. The value of this "niche" is estimated at £360m in the UK alone (Fresh Fruit & Vegetable Bureau)

Currently, supermarket retailers are the major channel to the consumer with around 70% of all organic sales

Importance of Marketing

The facts and figures above give a good overview of the trends in the market for organic food. They show that there is clearly potential for local producers. To access this market successfully however requires careful planning, linking the right product to the right buyer. This is marketing.

What is involved?

The first step is to identify the customers e.g. supermarkets, local shops, restaurants or direct retail (farm shops, home delivery "box schemes")

Next, liaise closely with buyers to establish their requirements. These will revolve around the 4 P's:

Product, Place, Promotion and Price

Other areas such as packaging, presentation and distribution are also becoming increasingly important. The key is understanding not only the customer but the end consumer.

A marketing plan should be prepared assessing all the market opportunities and your business's capability to service them

It is only at this stage that decisions on how to develop the business can be made

The marketing function is not confined to this initial phase of development but is an ongoing and integral part of the business. Success of the business depends on this

The key to good marketing is
continued regular communication with the customer!

Accessing the Market

If the chosen market involves a direct approach, straight to the consumer, the market research requirement is greater.

It is essential to identify if there is a large enough local population interested in organic produce and able to pay the higher prices it demands.

Working through other retailers, particularly the multiples, reduces direct involvement with the consumer. It also removes the need, in most cases, to be producer, packer and processor.

These services, being specialised, are generally provided by a separate company. This is mainly due to the demand of the retailer for quality, continuity and volume; three factors that are difficult to govern as an individual grower.

Marketing organisations e.g. meat plants, dairies or vegetable packers and distributors will draw on a pool of produce and are much better placed to manage large retail accounts.

In accessing the market place these organisations can be of invaluable assistance.

Market Research

There are broadly two categories of market research:

Desk or secondary research, which is carried out through literature reviews, telephone consultations and employing IT services such as the internet

Field or primary research, which will involve direct contact with the intended customer via surveys or focus groups

Both methods of research are useful but primary work will generally give the most accurate picture of the potential market requirements. Secondary research indicates the trends in the market place and is used in initial investigative work.

Desk research, employed for this leaflet, has shown the market for organic food to be expanding and that the potential for import substitution is enormous.

However this does not mean that any business can take advantage of this opportunity. Tailored primary research is necessary to relate the market potential to an individual business.

This work can be carried out by anyone but is very often undertaken by marketing consultants who will prepare a full report on the market potential.

Whilst this can be expensive, it is a crucial first step and can prevent unnecessary losses in time and money.

Market Development Scheme

This scheme has been designed to improve businesses' marketing capability. It will assist with the costs of recruiting key personnel, employing a consultant and in the preparation of a business or marketing plan as part of a feasibility study.

The scheme is competitive and assistance is awarded on merit.

Contacts for further information

Marketing organic produce

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