Propagation of Vegetables©

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INTRODUCTION

Vegetables are grown for a variety of reasons and wherever man has settled long enough to produce crops, vegetables have been cultivated for human and animal food.

All around the world, vegetables were grown on the edges of major centres of population. Market gardeners took their own fresh produce into the city markets. The growing areas were often located on the very best agricultural land. As cities have spread, the market gardening areas have largely been subdivided for development. Some of the world's best horticultural land now supports houses and factories rather than vegetable production. A few of the traditional areas remain, however, with established vegetable growing families or new migrants waiting for a sufficiently attractive financial offer for their land.

Meanwhile, traditional market gardeners and new broad-acre farmers have moved well away from the cities and many vegetable production areas are now large, extensive, mechanised enterprises.

In other parts of the world, vegetables are grown in private gardens, homesteads, and subsistence farms where the crops are used to supplement family diets and incomes.

Vegetables are also grown in some communities for physical recreation purposes or as a pastime and hobby.

There are some small-scale producers who aim at self-sufficiency in vegetables plus a surplus for sale or exchange in village communities.

Commercial vegetable production has extended considerably in recent decades in many parts of the world, as field and protected-crop growers strive to provide continuity of supply for fresh markets in urban areas, value added and processing outlets, and for export.

Vegetables play an essential dietary role, providing fibre, carbohydrates, proteins, minerals, vitamins, and folates. In developed countries, the importance and value to health of vegetables is well understood even though consumption is not always adequate and balanced. Efforts are made in developing countries to encourage the supplementation of staple foods, such as rice or wheat, with green vegetables. Meanwhile, the medicinal advantages of vegetables are being investigated in developed areas. Examples include the properties of garlic and onions.

Leguminous vegetables can be used in arable farming rotations in order to increase soil nitrogen status. They are also used as a rotational break in broad-acre production systems for crops such as cereals. In developing countries, vegetables are often grown as a cash crop with supplies earning valuable foreign currency from processing outlets or export markets.

Technological advances in processing and value-adding have led to demand for increased quantities of a more diverse range of vegetables. Coupled with this have been major improvements in large-scale vegetable production technologies. These include advances in weed control, improved methods of crop establishment, more efficient monitoring and application of irrigation water, development of integrated crop management systems, and adoption of hybrid cultivars to improve crop uniformity.

Consequently, vegetables play an important role in dietary, social, and economic well being of communities all around the world. Increasing interest in vegetables has led to national and international activities to develop reliable and cost-effective propagation methods based on seed and/or vegetative systems.

PROPAGATION OF VEGETABLES

Most vegetable crops are grown from seed with only a few being propagated vegetatively. Examples of vegetatively propagated crops include; cassava, garlic, ginger, globe and Jerusalem artichokes, potato, rhubarb, sweet potato, sea kale, and yams.

The input cost of seed is extremely low when expressed as a percentage of the total value of all inputs used in producing a vegetable crop. For example, it is approximately 15% for direct-drilled carrots, around 7% for transplanted cauliflowers and less than 1% for a long season tomato crop grown in heated glasshouses.

Vegetative Propagation. As with all forms of vegetative propagation, the principle for vegetable crops is to use parts of mother plants as the starting point for the next crop.

Mother plants are selected for desirable characteristics, including yield, season of production, growth habit, freedom from disease, resistance or tolerance to pathogens, food value, crop quality, etc. In many instances, mother plants are simply identified in growing crops and then used as a source of propagation material.

In other instances, such as potato and sweet potato, there are scientifically-based certification schemes in several countries of the world, which commence with virus-free tissue-cultured material. With potatoes, newly bred or selected parent material is initially propagated in vitro to remove all known viruses. The clean material is then maintained in vitro as the source for future propagation.

Traditional potato certification schemes utilise tissue-cultured plantlets, grown in insect-free greenhouses, to produce the first generation of high health status propagation material — known as minitubers. The minitubers are used by specialist seed potato growers to produce the first field generation of tubers. Strict conditions are imposed for growing seed potato crops, including isolation from other potatoes, regular inspections and roguing to identify and remove diseased or off-types, and quality control of tuber production and storage.

It is usual for three or four field generations to be used to bulk up the material before it is sold to growers of ware potatoes for fresh market or processing outlets.

The last decade has seen the introduction of a modified system whereby tissue-culture raised transplants are used instead of minitubers to produce the first field generation of tubers.

Most recently, an even more intensive system has been developed in Australia and other countries based on the hydroponic production of fingernail-sized tubers or microtubers. Tissue-culture plantlets are grown in an aeroponic system to produce microtubers that are successionally removed. After hardening and storage the tiny tubers are planted into the field. They can be planted with conventional seed sowing equipment calibrated for large seeds. Microtubers are, again, used as the starting point for the first field generation and have the advantage that the numbers required to plant large areas occupy significantly less space than traditional minitubers and are, thus, much easier to transport.

With every additional field generation to bulk up the certified seed there is an increased risk of re-contamination. A balance is always struck to ensure that high health status planting material is available to commercial growers at an acceptable price.

Vegetables that are normally propagated vegetatively also produce true seed but, in most instances, this is not used to grow subsequent crops. However, research workers at the International Potato Center (CIP) in Peru have demonstrated the value of producing commercial potato crops from seed, especially in developing countries. The term now accepted for seed of this crop is “true seed” or “TPS”, which distinguishes it from tubers.

PROPAGATION FROM SEED

The Seed Business. Seed is an international commodity with private and public sector organisations producing seed in over 150 countries. As with many other businesses, takeovers and mergers are reducing the number of seed companies in the world.

Seed companies are tending to concentrate production in countries where the climatic conditions and the costs of investment and labour are favourable. Most vegetable seed is no longer produced on the off-chance but, rather, according to planned long-term or short-term stock requirements. All the international activity and trade means that seed can be subject to price fluctuations, or inflation due to variations in international exchange rates.

Plant Breeders Rights. The granting of plant breeders rights to the breeder of a new cultivar provides protection to the breeder or the breeder’s company or institute, from the multiplication or reproduction of the cultivar by unauthorised persons.

The registration of a new cultivar and the description of its distinct characters with a registration authority, which is recognised by law, protects the breeder from unlawful reproduction of the material by persons in countries that have adopted the system of plant breeders’ rights.

The Convention of The International Union for the Protection of New Varieties of Plants (UPOV) was set up to ensure that plant breeders can have exclusive property rights for their new cultivars. The main criteria for a cultivar to be included for protection are that it is distinct from existing, commonly known cultivars, sufficiently homogeneous, stable, and new (i.e., not been commercialised before certain stipulated dates).

Guidelines are published by UPOV for the conduct of tests for distinctness, uniformity, and stability (DUS) in many crops. The criteria for DUS testing depend on the species but characters such as morphology, time of flowering, and resistance to specific pathogens are useful where they are not affected by environment.

Cultivar Identification. A number of chemical, biochemical, and genetic techniques are available for identifying and distinguishing vegetable cultivars. Rapid chemical identification methods include phenol tests, fluorescence tests, the use of chemical bases, and chromosome numbers. A fluorescence test can be used to distinguish fodder peas from garden peas. When viewed under ultraviolet light (wavelength around 360 nm) the testas of fodder peas fluoresce but garden peas do not.

Determination of chromosome number can be used as a method of classifying beet seedlings according to their ploidy. Young roots are fixed and stained prior to microscopic examination, when diploid cultivars show 18 chromosomes, triploids 27 chromosomes, and tetraploids 36 chromosomes.

Electrophoresis is a well established biochemical technique and can be used for cultivar identification. It is a technique used to separate charged particles under the influence of an electric field. Different sorts of support media are used to hold the charged particles during separation, including polyacrylamide (hence PAGE - polyacrylamide gel electrophoresis). Different cultivars produce distinctive separation patterns.

DNA profiling techniques can also be used for cultivar identification. Probe-based profiling requires the use of radioactively labeled probes and, hence, has restricted use. However, it has been used to fingerprint maize hybrids and breeding lines. Amplification-based DNA profiling is relatively new and referred to as random amplified polymorphic DNA (RAPD). It is being increasingly used for cultivar identification and verification since it does not involve radioactivity, is relatively quick and can be automated. It is already used in Australia to identify wine grape and potato cultivars.

Organically Produced Seed. Growers of organic vegetables are now requiring that seed from which those crops are grown is also produced organically. Hence, the nutrients must only be derived from animal manures, nitrogen-fixing crops, and approved organic and mineral materials.

Undesirable crop or weed seeds must not be introduced with uncomposted organic materials. Synthetic crop protection materials should not be used and the control of pathogens, pests, and weeds must be achieved by nonchemical means — such as choice of cultivar, crop rotations, encouragement of natural parasites and predators, and timely cultivations.

Pre-sowing Seed Treatments. Pre-sowing treatments that are used for vegetable seeds include the use of pesticides for the control of seed-borne or soil-borne pathogens, modification of seed shape or size, and pre-germination before sowing.

Seed treatments for the control of pathogens range from the application of chemicals to the seed as dusts or slurries, to the application of heat via hot water, dry heat, or steam-air mixtures. Seed-borne nematodes are controlled in onion and leek seed by fumigation with methyl bromide but the future of the technique is in some doubt due to proposals to limit the use of methyl bromide because of its harmful affects on the environment.

Seed pelleting facilitates the manual and mechanical handling of seeds that are either small or awkwardly shaped. Individual seeds are encased in an inert material, such as montmorillonite clay, in a process usually carried out by specialists on behalf of seed companies.

Seed coating, or film coating, is a technique by which additives such as pesticides, nutrients, or nitrifying bacteria can be applied to the outside of seeds. In contrast to pelleting, the coating conforms to the seed shape and does not normally modify the seed's size.

Priming and moisturisation are the two main hydration treatments for vegetable seeds. Priming is a pre-sowing treatment that aims to bring all the seeds in a seed lot to the same stage (on the brink of germination) before sowing. The main method of priming utilises polyethylene glycol (PEG) to control water uptake by seed. Use of different concentrations of PEG solution for different vegetable seeds allows close control through the use of osmotic pressures. Primed seeds can be dried back and stored before sowing.

Moisturisation of bean seeds may be used as a method of enhancing emergence. Seeds with a low moisture content are prone to mechanical damage as well as low germination. Improvements occur when the moisture content is adjusted to around 12%.

Effect of Seed Storage. The two most important environmental factors that affect seed quality during storage are temperature and relative humidity. Vegetable seed most suitable for storage has a moisture content not greater than 10% of seed weight. It is extremely vulnerable in this state however, and quickly takes up water again unless relative humidity is carefully controlled.

The loss of seed viability is slower at lower temperatures than at relatively high ones. In practice it is the combined effect of temperature and relative humidity that reduces the potential longevity or viability of seed throughout its storage life. This is an extremely important consideration in areas of the world that have periods of fluctuating temperatures coupled with periods of high relative humidity.

Harrington (1963) provided two useful “rules of thumb” for temperature and relative humidity; for each 1% reduction in moisture content the storage life of the seed is doubled, and, for each 5^{o}C lowering of the storage temperature the storage life of the seed is doubled.

FACTORS INFLUENCING VEGETABLE SEED PRODUCTION

Plant Nutrition. Studies on the effect of mother plant nutrition showed that different ratios of nitrogen and phosphorus influence seed yield and quality. Research with *Phaseolus vulgaris* showed higher yields as nitrogen levels increased but even greater responses when high levels of nitrogen were combined with high levels of phosphorus (Browning et al., 1982).

Plant Population. Carrot seed yield increases with plant population. Gray (1981) showed that significant seed yield increases were obtained with crops grown from seed and with those grown from re-planted roots (stecklings). A plant density increase with stecklings from 100,000 to 800,000 per hectare raised seed production by 60% while an increase in seedling plant population from 110,000 to 2,560,000 plants per hectare resulted in a 35% increase in seed production.

Plant Growth. The position, and thus maturity, of seed in the carrot inflorescence at harvest has been shown to influence the time that seeds take to germinate at different temperatures. Thomas et al. (1978) and Gray (1979) showed that seeds from primary umbels germinated 4 to 6 days faster than those from secondary umbels at low (5^{o}C) temperatures. The difference was reduced to 2 to 3 days at 25^{o}C. Since there is less branching and a higher proportion of primary to secondary umbels at high plant densities, commercial carrot seed production now concentrates on high plant densities.

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Fruits of the Forest: Exploring Australia's Tropical Rainforests for New Pharmaceuticals and Industrial Chemicals©

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Many of the chemicals on which our healthcare and agriculture rely originate from "leads" provided by nature. For example, approximately one in four prescription drugs used in the developed world are derived from tropical plants. However, a major limitation to the discovery of new chemicals from nature is the enormity of the tasking using current approaches which are largely random, time consuming, and costly. Recently we have developed a powerful new approach to discovery of "bioactive" chemicals based on our knowledge of the ecology of Australia's tropical rainforests. This approach very effectively targets sources of bioactive chemicals in nature and is helping us unlock the very rich, but largely untapped, chemical diversity of our tropical forests. In this presentation, we illustrate this approach with an example from our work on chemical defences in fruits and seeds of Queensland rainforest plants.

There are more than 1800 species of flowering plants in Australia's humid tropics and they exhibit a striking diversity in size, shape, colour, form, fruiting patterns, and dispersal mechanisms for their fruits and seeds. On the basis of ecology we predicted that because they are the propagules for future generations, fruits and seeds of rainforest plants would have a proportionally greater investment in defence (chemical and other) than would other plant parts. We further postulated that chemical defences would be:

1) Strongly developed in certain ecological groups against specific types of predators and pathogens;
2) Highly localised and potent within the fruit due to biological "trade-offs" inherent in packaging, protection, and dispersal of propagules.