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Container Cropping for Increased Crop Production

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Abstract
Globally, there is a reduction of arable land due to constant increase and expansion of cities and other environmental problems. Container cropping becomes imperative among city dwellers as a measure to meet up with increase in demand for quality edible crop products. To achieve optimal crop growth and yield in container crop farming, prospective gardeners should be careful in the choice of container, growth media, planting materials and environment. The individual or collective impact of these factors on container crop production is outstanding.

Keywords: Container farming, gardeners, optimal production, principles

Introduction

The growing of crops in containers or pots containing soil, soil amendment or soilless materials is known as container cropping. Other names for this fast developing and diversifying cropping method are container gardening, pot farming, pot agriculture, pot horticulture or crops in pots. Initially, this farming practice was exclusively carried out for experimental purpose, in that it enabled workers or researchers to overcome any limitation or barrier in growing any crop of interest. Crops were grown in pots to have them in a controlled environment for improved observation, either on the crop or its environment or both. However, in recent times, crops are now grown in containers because it is an easy and successful way of farming. The benefits of growing crops in pots are numerous. It is easy to get started with, especially for those who are new to farming, as it requires less management. Again, it is not stressful as it does not involve digging and tilling. Cropping can be done at the farmers convenience - time, location (balcony, deck, stoop, concrete pad, or any part of the yard), and where adequate attention can be given to the growing condition (water, sunlight, nutrients) of the crop, in order to protect it from extreme weather conditions, and attacks from insect pests. In addition, all classes of people irrespective of age, social or economic status can be involved in container cropping; hence it is gaining more acceptance in the society. In fact, it can lead to higher yields with less work than a conventional garden. Container gardening has outstanding aesthetical, nutritional, and economic values (Univ. of Maryland, 2016).

The popularity of container gardening as a viable way of cropping in agriculture is no longer in doubt, and so far, has shown potentials of complementing field cultivation of crops to improve crop production. However, for this farming practice to be completely successful, it should significantly improve crop productivity, which is the basic goal of any agronomic practice. A recent preliminary survey carried out among urban and semi-urban dwellers on container cropping shows that over 90% of those who practice it do not have the basic knowledge on the cultural practices or techniques of pot farming (ADP, 2016). In other words, the choice of base materials used in the formation of the growing media do neither follow any pattern, nor the type of containers used for planting, in relation to the crops planted. This is further confirmed by the poor harvest recorded by some of these farmers (ADP, *ibid*). Invariably, there is paucity of information on overall practice of container cropping. This condition hampers farmers' efforts to effectively explore pot farming for optimum crop production. Consequently, the need for a critical review on the current practices' *vis a vis* the standard cropping technique. The importance of this review paper in the development of container gardening cannot be over emphasized. Among others benefits, waste of human and material resources experienced in some failed container gardening will be drastically reduced if not eliminated. Furthermore, it will strengthen and encourage more people to explore container cropping as a viable, less stressful, novel means of cropping, with the ultimate goal of increasing food production. The aim

of this study was therefore to guide prospective gardeners on best practices on growing crops in containers.

Materials and Methods

The materials required for successful container cropping are container(s) or pot(s), medium or media, and planting materials. Containers or pots are objects used to hold or house something, in this case to house the media and crops. It can come in various sizes, shapes, colours etc. In the past, sizes, shapes and colours were not considered as important factors, especially the latter in choice of containers for pot farming. Workers did not envisage that variations in any of these parameters (sizes, shapes, colours) may have any effect on the germination and growth of the crops in containers. However, the effect of container size became obvious with time as it was observed that potted crops out grew the containers, necessitating re-potting with bigger containers. Funk *et al.* (1980) reported that larger containers appeared to produce larger trees and seedlings grown in conventional shaped pots were 123% heavier than others. It was also reported that tomatoes and vining crops, such as cucumber, will do best in containers 20 inches or more in diameter, and the performance of pepper is enhanced in pots that are at least 16 inches in diameter or more (John *et al*., 2011). For root crops, a deep container is a must to have for optimum growth and to facilitate earthing up for crops such as potatoes. John (2010) reported that colour and shading of containers affected root-zoon temperatures and growth of nursery plants. The colour of container plays a vital role in the attraction of insects to growing crops in containers - either as a pollinator or pest. Generally, bright colours like yellow, red, light green etc attract insects (pollinators or pest) while dull colours do not. Dark colors absorb heat, so they can make the soil too warm for some vegetable crops during the dry season. Apparently, the size, shape and colour of containers may positively or otherwise affect container crop production. A good media for container gardening should function basically like soil. It should provide physical support (anchorage) and nutrients, air and water to crops. In addition, it should be spacious enough to enhance maximum crop growth. To achieve this, depends wholly on the choice of base materials used in the formation of the media. The base materials of a media determine its physiochemical properties (Sahin *et al.*, 2005; Baiyeri and Mbah, 2006).

Anchorage: One of the primary functions of soil is to hold the crops firm. The roots of crops secure them in the soil; thereby helping them to withstand the effect of strong winds that can make the crops fall (lodging). Therefore, any good media must provide good anchorage for crops. However, the root system of crops affects their anchorage. Fibrous roots crops seemingly anchor their roots on the surface of the soil through a network of fine roots, unlike tap root crops that grow their roots straight down into the soil (Figure 1). This has some implication on the choice of base materials for the formation of growing media and the container for different crops. Growing media for fibrous root crops should not be formed from light and fluffy materials in terms of strength; rather it should comprise of materials that can provide strong physical support to shallow roots of fibrous crops. Invariably, the strength of the base materials to be used to form media for the planting of fibrous root crops should be stronger to that for tap root crops, since the latter has a deep rooting system. Again, the choice of container for fibrous root crops should reflect the spreading nature of the root system along the surface- hence it should be wide enough. On the other hand, containers for tap root crops should have depth to accommodate its deep rooting characteristics. Furthermore, the materials for the formation of the media should be such that can provide nutrients at any depth, enable proper drainage which helps in the maintenance of appropriate temperature suitable for crops to grow as against water-logged condition. Invariably it should be a low bulky density medium.

Nutrients: The primary essential nutrients needed for plant growth and survival are nitrogen (N), phosphorus (P), and potassium (K), magnesium (Mg), calcium (Ca) and sulphur (S). Therefore, materials that will be suitable for the formation of media for container cropping must be rich in these elements. In addition, choice of materials should also reflect the specific nutrient requirement of the crop or crops to be grown; nutrient requirement of crops differs according to types and sometimes stages of growth. Again, it is also important to know how base materials release their nutrients to the crops, for example, fast nutrient mineralization is associated with base material that contains poultry manure, as against nutrient immobilization observed for cow dung base cropping media (Gana, 2009; Onwubiko *et al.,* 2015a).

Aeration: Air plays a very important role in the germination and growth of crops. For seed germination to take place, air must be present. Studies have shown that the relative balance of air and water within a soil's pore space is critical to plant growth (Bruckner, 1997; Caron and Nkongolo, 1999). The synthesis and metabolic activities (cell division and differentiation) that facilitate root development require sufficiently aerated medium. Plant roots get oxygen from air in the soil pores spaces. Again, in nutrient management, soil aeration influences the availability of many nutrients to the crops; in that soil air is needed by many of the microorganisms that release plant nutrients to the soil. Therefore, appropriate base materials for container cropping should be sufficiently aerated. Poor aeration like low porosity retard root development in plants (Gana, 2009, Baiyeri and Mbah, 2006).

Water: Soil moisture is the term used to describe water contained in the soil and it is found in the soil pores. Soil water is essential in the growth of crops as it acts as nutrient itself and also dissolves other nutrients. Invariably water is the medium that carries nutrients that plants need to fuel their growth. Again water is essential

for seed germination to take place. Seed absorbs water through micropyle, which swells it, causing the seed coat to burst. This helps the root to emerge out of seed. Water absorbed by the germinating seed help to activate the enzymes to digest the food in the seed, which will be made available to the growing embryo. It also helps to elongate hypocotyl and epicotyl. Soil forming processes and weathering depend on water. Microorganisms that live in the soil require water for their metabolic activities. Also soil water helps in chemical and biological activities of soil. On the other hand, it is important to note that an increase in soil water content often causes a reduction in soil aeration and vice versa. An appropriate balance between soil air and soil water must be maintained since soil air is displaced by soil water. This is a critical issue in managing crop plants (Bruckner, 1997; Caron and Nkongolo, 1999).

Types of Potting media

(a) Soil -The common practice of container gardening has been as simple as having some top soil in any container or pot for the purpose of growing crops or plants. However top soil in containers have two major shortfalls; poor aeration and drainage problems, and this often result in hardening of the soil in the container. Again, soil may be contaminated with materials like weed seeds, spores of disease-causing organisms, insects etc. Another problem of soil in containers is that it is bulky. Sometimes it is difficult to carry the container from one location to another. This led to the search for other materials to amend the soil.

(b) Soil amendment- soil amendment for growing crops in pots describes a situation in which top soil is mixed with other materials at different ratio to help improve its quality: reduce its bulky nature, improve fertility, drainage, aeration, and inhibit the growth of diseasing causing organisms. Some standard soil amendment formula for research experiments reported by workers includes 3 volumes of soil, mixed with 2 volumes of poultry manure, and 1 volume of river sand, and one volume of top soil mixed with one volume of poultry manure. Several significant research works have been carried out by workers on growing of crops on amended soil (American Society of Agronomy, 2017; Collins *et al*., 2013; Landschoot, 2013; Baiyeri and Mbah, 2006; Onwubiko *et al.,* 2015). However, in recent times, soil amended with other materials is no longer considered the best practice in media formation for container gardening, rather the use of materials other than soil. This noble idea is attracting more research attention from scholars than the use of other cropping media in container cropping.

(c) Soilless media- Recycling and use of waste materials for cropping (container gardening) is a fast-growing area of study that is attracting a lot of attention in agriculture and agro based industries, and this is opening up new ideas and more employment opportunities in agriculture. In recent times, soilless mix is solely and conveniently used in growing crops in containers. This describes a condition where soil was not used to grow crops. Soilless mix for planting crops in pots gives the grower a full control to blend nutrient rich materials to grow crops. Such media is scientifically or systematically developed to meet the various or specifics cropping needs of different types of crops. Soilless mix is not only free of contaminants, but also designed to achieve preferred level of porosity, aeration, bulk density to grow specific crop of interest. In addition, the use of soilless media for cropping is supporting in no small measure waste to wealth concept of waste management. Most materials used for the preparation of soilless cropping media range from kitchen refuse through organic municipal waste to those from small scale agro-industries. The successful use of soilless mix in the growth of crops have been reported (Baiyeri and Mbah, 2006; Onwubiko *et al.,* 2015b).

(d) Organic farming – Initially this refers to the addition of organic matter to the soil to improve it, in which no chemical fertilizer or pesticide is added. In more recent times, educated farmers emphasize that organic farming refers to the use of only organic materials in farming. The potting media may be composed of the same or different organic materials. A typical example of organic farming is compost farming. Compost is the dark, crumbly, earthy-smelling product of decomposing organic matter. Leaves, grass clippings, wood waste, and farm animal manures are some of the common ingredients that are used in the formation of media for organic farming. It is believed that organic media will give your vegetables better flavor.

(e) Commercial Soil-Less Mixes: In some countries especially the developed countries, amended soil or soilless mixes used for cropping are acquired from their producers (institutions or companies or their sales agents). In fact,

commercial amended soils or soilless mix are an excellent choice for container farming. They have good physiochemical properties for cropping; are lightweight, good drainage, able to hold water and nutrients, and are generally free of weeds, insects, and diseases. They have a pH of about 6.2 and are typically comprised of sphagnum peat moss, perlite, vermiculite and small amounts of lime and fertilizer. Generally commercial soil-less mixes vary greatly in composition and quality. Examples of soil-less mixes used by farmers in the U.S. are ProMix™, ReddiEarth™, Jiffy Mix™, and Sunshine Mix™ (Univ. of Maryland, 2016). Summarily, a good media mixture for container vegetables should fall into any of the categories listed below-

1. 100% compost
2. 100% soil-less mix
3. 25% garden soil + 75% compost
4. 25% soil-less mix + 25% garden soil + 50% compost
5. 25% garden soil + 75% soil-less mix
6. 50% soil-less mix + 50% compost (Univ. of Maryland, 2016).

Planting materials: A good seed or planting material is as important as a good media. No good media can give a good yield without a viable seed. In the past seeds/planting materials were acquired or inherited from associates, colleagues, parents, and elders. This culture is still in practice to an extent till date among resource poor farmers. Unfortunately, seeds lose viability as they age. Bambara groundnut seed lose viability when stored for over 18 months (Goli *et al*., 1999). Also, open pollinated crops like maize lose homozygosity after 3 years of constant cropping. Therefore, seeds for container cropping are best sourced from government agricultural ministries or agencies and seed producing companies. Certified seeds or planting materials are released with instructions on specifications to ensure best results.

Tips to growing successful healthy vegetables in containers

1. It is important to drill holes at the bottom of containers.
2. Raise pots with flat bottom off the ground to a reasonable extent.
3. Avoid drying up of the potting media, moisture is lost much faster from a container that is directly open to sunshine or that is on the soil - regularly inspect the vegetables and water the crops.
4. Remember to revitalize soil used in the previous cropping season before reuse for the current season, otherwise it may be deficient nutritionally, infectious, and may be hide out for dangerous insects and reptiles.
5. Containers used to store strong chemicals should be avoided in growing vegetables, as it may contain chemical compounds that could be absorbed by your vegetables.
6. Instantaneous action should be carried out for pest and diseases problems.
7. Adjust the environmental conditions in which you want to grow your crops to suit optimum growing condition of the crop. Sun loving crops should not be grown in shades to avoid unhealthy crops and low yield.

Conclusion

Making effective use of most of our lawns and paved surfaces, by growing edible crops for year-round garden may be more than an adventure. It can provide nutritious food for a healthy living, economically improve lives, and bring unique fun for socially satisfaction. However, container cropping is not just growing crops in container containing soil. There are more to success in container crop production.

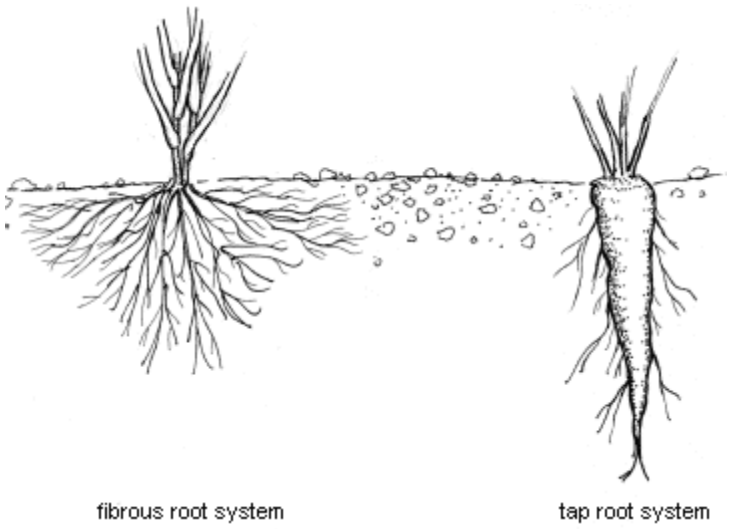

Figure 1: Root Systems in crops.
(Adapted from U.S. national garden association)

Plate 1: Picture of some healthy vegetable crops in containers (adopted from savvy gardening)

Table 1: Possible production problems and their control in containers

Problems	Causes	Control
Seedling's emergence failed after sowing.	Temperatures may be cold. Soil may be too dry or wet; seeds may have been rotted. Birds or insects ate seeds. Old seed that is no longer viable.	Water. Replant with fresh seed.
Wilting of Seedlings and fall over. Young plants die.	Dry soil. Damping off (fungal disease). Rotting roots or stems. Fertilizer burn. Cutworms. Root maggots. Old seed.	Keep soil evenly moist. Bottom water seedlings growing indoors. Avoid overwatering. Sow seed in sterile seed-starting mix. Treat soil with fungicide
Wilting of plants.	Low soil moisture or excess water; poor drainage; waterlogged soil. Disease like Root rot (fungal disease). Vascular wilt (fungal disease often affecting tomato, potato, eggplant, pepper). Root knot nematodes.	Water deeply, thoroughly. Water when soil is dry to a depth of 3 or more inches. Stop watering; improve drainage. Grow disease-resistant varieties. Keep garden weed free and clean.
Slow growth rate: leaves are light green	Sunlight received is Inadequate, shading of garden. Cool weather; low temperatures. low soil pH, excess water.	Reduce number of plants to recommended density. Ensure that plants receive 6 to 8 hours of sunlight each day. Test soil pH. If alkaline, add soil sulfur, aluminum sulfate, add aged compost, peat moss. Do not overwater. Improve drainage by adding aged compost and organic amendments to soil. Grow crops in raised beds.
Curled leaves, puckered, or distorted	Wilting. Disease caused by Virus. Aphids. Moisture imbalance. Injury caused by herbicides.	All infected plants must be removed and destroy affected plants. Practice crop rotation. Plant disease-resistant varieties.
Curling down and edge rolling of young leaves. Distortion of Leaf surface and veins turn light color.	Weed killer damage.	Discontinue the use of herbicides. Remove weeds with hand.
Leaves marked with tiny white spots	Spider mites. Air pollution (ozone).	Use insecticidal soap to spay the plants or treat them with registered miticide. Leaves can be washed with water; ensure they are dry before night.
Upper surface of leaves, stems, and flowers coated with powdery white substance.	Powdery mildew (fungal disease); occurs when leaves are dry, but weather is humid.	Grow resistant cultivars. Plant spacing should be wide to ensure good air circulation. Plant in full sun.
Holes on Leave; seedling and fruits chewed.	Insects, slugs, birds, rodents, rabbits. Heavy winds or hail.	Identify the pests; and use all the instruments that can deter these pests from invading the crops like slug bait, nets, fencing etc
No fruit.	Cold Weather; low temperatures. Hot Weather. Excess nitrogen. No pollination. Plants not yet matured.	Plant to synchronize flowering with insects blooming, to attract pollinators to plants. Don't harm pollinating insects.
Poor fruit yield; small fruit; poor flavor	Uneven distribution of soil moisture. Poor soil fertility. Inappropriate temperature.	Mulch aged compost or manure to retain soil moisture. Deep and even watering is essential especially during dry periods.

Source: Harvest to table (plant, prepare and preserve)

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