Growing vegetables in sandy soils

Some ideas and suggestions for improving the productivity of vegetables growing in sandy, infertile acidic soils in a windy Mediterranean climate.

I found out about Stellenbosch University's research into using biochar to grow vegetables on the Cape Flats on the internet. I am a horticulturist living in Cairns, Australia; however I grew up (and gardened) in the Southern suburbs of Cape Town. I think the research you are doing is extremely important, and I would like to add some suggestions that might be useful. I appreciate that you will already be aware of much of this information, but I hope that some of it will be helpful.

Zai holes

Zai holes are a technique used in West Africa to grow sorghum in poor soils, and in East Africa the Tumbukiza method is used to grow large, fast-growing fodder grasses such as *Pennisetum purpureum* (Napier grass or elephant grass). Holes of various sizes are dug, and animal manure is mixed in. In some places termites disperse the manure out of the hole and into the surrounding soil, and earthworms may do this in other places. Zai holes are usually 20 – 40cm in diameter, and 10 - 20cm deep, spaced 80cm apart, and Tumbukiza are square or rectangular trenches with sides 40 – 90cm and depth 40 – 90cm. Some of the subsoil is used to form a rim around the hole on flat ground (to hold water in), or around the lower edge of the hole/trench on slopes to catch water. The space/paths between the holes act as a water catchment area – larger areas and smaller holes providing more water for each hole in arid regions. Tumbukiza trenches increase plant productivity around 4 times and Zai holes from a 75% increase up to 6 times. Compost and biochar should give similar or perhaps better results than animal manure. In at least one case, biochar has been used successfully in Zai holes, see http://globalwarming-arclein.blogspot.com/2009/07zai-holes.html.

See also www.echonet.org/content/article/1374/DRYLAND%20TECHNIQUES%20AN...,

http://biochar.bioenergylists.org/nepad19zai2004

and http://www.fao.org/ag/AGPC/doc/Newpub/napier/tumbukiza_method.htm.

The addition of organic matter such as cow or goat manure, or compost or biochar, plus catching additional water should therefore result in at least a 75% increase in plant growth.

Biochar

Biochar added to acid sandy soils may provide a number of benefits, such as an increase pH, water holding capacity, cation exchange capacity and perhaps promote beneficial micro-organisms. Biochar should act like a bank of long-lasting organic matter in the soil. If vegetable seeds are sown in trays with a medium of perhaps 50:50 biochar and coarse sand, this may be a good opportunity to inoculate the seedlings with mycorrhizal fungi or other beneficial micro-organisms. Biochar may also work synergistically in sandy soil if combined with compost which provides food for soil life in the short term, and clay such as bentonite/montmorillonite.

Biochar could be made using invasive weeds such as pines, wattles and hakeas.

Burnt bone

The phosphorus in burnt bone is reputed to be more available than bone that has not been heated. In Gillman (2008), raw bone meal is stated to be 22% P. The Rodale book of composting states that burnt bone has around 30% available phosphorus, while Peter Bennet in his book "Organic Gardening" states that burnt bone has a very high phosphorus content of up to 35% phosphoric acid equivalent, compared with unburnt bone at 21%, and unburnt bone may not release its phosphorus for hundreds of years (Bennet 1995). Burnt bone (from mammals, fish, and poultry) could be home-made, or may be available as a waste product from the sugar industry.

Animal bones could be burnt with wood or other biomass, perhaps in a proportion of one part bone to three or more parts wood/waste biomass, and ground into powder. The temperature required to do this may be higher than is required for producing ideal, high porosity biochar, and may be best treated as a separate process.

Charring manure may also increase nutrient availability. In a traditional cropping method in Ethiopia, dry grass, clay soil and manure are slowly burned together in piles, resulting in an increase in the availability of phosphorus and increased alkalinity (Troeh *et al.* 1980).

Vermicompost

Earthworms can improve nutrient availability to plants and thus increase plant productivity. Organic matter and mineral particles are exposed to grinding action and bacterial activity as they pass through earthworms so that nutrients are more available in the casts/compost they produce.

Black soldier fly larvae, *Hermetia illucens* can also be used to produce compost, and may do better in hotter, drier conditions/seasons than earthworms. I am not aware of any research in the area, but nutrients in organic matter/mineral particles that have passed through black soldier fly larvae may also be more available. The larvae are also used as live food for reptiles and fish, and may be available from pet shops.

Some dramatic figures for increased nutrient availability in vermicompost (or worm casts) can be found in many books, but results from research in Nigeria provide a more likely result. Lal et al. (1982) found that increasing amounts of N and P fertilizer resulted in increasing nutrients in worm casts, and nutrient status of casts in no-till plots was generally superior.

Worm casts, compared to the top 10cm of soil, contained:

Organic matter: 1.5-2.3 times more than the top 10cm of soil

C.E.C.: 2.1-3.1 times higher

N: 1.2-1.8 times more N

P: 1.3-1.6 times more Bray-P

K: 2.3-3.1 times more exchangeable K

Ca: 2.1-3.2 times more exchangeable Ca

Mg: 2.5-3.8 times more exchangeable Mg.

Research in New Zealand has shown a threefold increase in plant-available phosphorus in soil that has passed through earthworms, and available water increased from 1.8mm/cm to 3.1mm/cm.

Contrary to popular opinion, low to moderate rates of chemical fertilizers can increase earthworm populations (more fertilizer equals more plant growth providing more food and mulch), and increase the nutrient content and availability in casts. For example, growth responses of *Amaranthus tricolor* (a leafy vegetable) in Bangladesh, increased with increasing applications of vermicompost (up to 10 tonnes per hectare), with vermicompost superior to NPKS chemical fertilizer, with the best results when NPKS fertilizer was added to the vermicompost. The combination spectacularly increased growth by about 305% (13.25 t/ha), compared with the control (Alam *et al.* 2007). If the same amount of chemical fertilizer had been fed in small doses over time to earthworms, the resulting vermicompost might have had still higher nutrient availability, and even better growth response.

Burnt bone could be added to worm farms to produce vermicompost with very high phosphorus availability. Vermicompost which includes burnt bone and biochar that has been fed to worms could be called "vermicharmpost". Finely ground rock phosphate fed to worms should also become more available. Other materials which could be added to worm farms to increase their nutrient availability would include rock dusts such as basalt, dolomite, lime, gypsum, granite etc. and small quantities of chemical fertilizers. The nutrients in chemical fertilizers which have been through earthworms and become vermicompost should be more available to plants and less likely to be lost through leaching, and so provide a very cost effective fertilizer. The superior vermicompost with highly available nutrients could be pressed into ice cube trays and the cubes placed beneath vegetable seedlings at planting, or below drippers, and/or the vermicompost could be side-dressed later.

Earth worms and black soldier fly larvae are a valuable feed for chickens, Guinea fowl and ducks, and are also used in aquaculture.

Beneficial micro-organisms

Beneficial micro-organisms include for example, Mycorrhizal fungi and nitrogen-fixing bacteria. Adding these to soils may or may not work extremely well. In the best cases, growth may increase manyfold. If there are no local suppliers, www.fungi.com in the U. S., or www.yladlivingsoils.com.au in Australia may be able to supply them.

Clever clover, Lucerne and mulch beds

Dr. Richard Stirzaker, a South African-born Australian scientist invented the “clever clover” system. In Mediterranean climates, this involves growing sub clover, *Trifolium subterraneum* cv. ‘Clare’, during winter, which adds organic matter and nitrogen, with the clover dying back in spring or early summer, leaving mulch for summer vegetable crops. This might also work with *Biserrula pelecinus*, which may die back a couple of weeks later than sub clover. This system has been tried-and-tested, and proven successful, by home gardeners in Australia for many years. A possible addition which might work well would be to use sub clover or *Biserrula* with a crop of broad beans to provide food and even more mulch, organic matter and nitrogen for a following crop of summer vegetables or cereals such as maize.

He has also experimented with growing un-irrigated lucerne (alfalfa) in alternate rows with irrigated vegetables, harvesting the lucerne every four to six weeks to use as mulch on the vegetables. This resulted in a yield increase of vegetable crops of up to 38% (Stirzaker 2010). Un-irrigated lucerne, bordered by irrigated vegetables on both sides, provided 13.5t dry matter/ha/year, containing approximately 400 kg N/ha, 30 kg P/ha, 200 kg K/ha and 250 kg S/ha.

For lucerne to grow well on acidic sandy soil, the soil would need an addition of lime (and/or dolomite, wood ashes, biochar) to make the soil closer to neutral, to at least 30cm depth. Lucerne and its foliage works well because it has little or no phytotoxic/allelopathic compounds, making an excellent mulch, and a deep root system (to 6 metres or more) which can gain access to deeper water and bring leached nutrients back to the surface. A winter-active variety would probably be best suited to the Cape Flats. *Biserrula* also has a deep root system and is better adapted to acidic soils.

Lucerne could be combined with other plants in “mulch beds”. In soil where lime has been added to grow lucerne, the indigenous, alkaline soil tolerant *Disparago anomala* could be combined with lucerne for mulch. Grasses may produce more mulch, and a grass and a legume growing together with different root systems and nutrient requirements may complement one another and produce even more material. In the tropics *Pennisetum purpureum*/bana grass would be the best, while in a Mediterranean climate, the sterile fountain grass *Pennisetum advena* cv. ‘purpureum’ might work well with some watering in summer, and with an underground water barrier (see section on water barriers). Some other grasses that may work include *Cenchrus ciliaris*, *Phalaris* spp., *Cymbopogon* spp. Other possible mulch producers could be *Dipogon lignosus* or any fast-growing indigenous legume, grass or Asteraceae spp., Comfrey and Jerusalem artichokes. A mulch bed may be more productive with a long-lasting plastic underground water barrier (see section on water barriers). Material for mulch or composting could also be collected from invasive weeds, for example the leaves, twigs and immature seedpods of wattles. Some of the best material is likely to come from *Paraserianthes lophantha.*

Mulch of cut wild grasses and banana leaves in East Africa has increased coffee yields by 22% to 93% (Troeh *et al.* 1980). Mulching vegetables is likely to increase productivity by 25% or more, especially in the dry season.

Water barriers

In sandy soil water tends to drain away too quickly for plants to use it. The water is lost, and nutrients are leached, causing additional problems of rising water tables, salinity and eutrophication of rivers and lakes. Soil amendments with a high water holding capacity and cation exchange capacity, such as biochar, can alleviate these problems. Underground water barriers can also be useful.

Experiments have been undertaken to assess the growth responses of various plants to placing an almost impervious 2mm thick layer of asphalt at a depth of usually 60cm below the soil surface, to hold water.

Erickson and others (in Troeh *et al.* 1980), placed horizontal asphalt barriers at 55cm to 60cm below the soil surface in a fine sand, with greater water availability resulting in vegetable crop yields increasing by 35% to 40%. Only small increases occurred on loamy sand (which presumably had a higher water holding capacity). In another similar experiment in sand the yield increase for capsicum was 45%, sweet corn 29% and sweet potato 42% (all in the U. S. A.). In South Africa, yield increases for cotton, lucerne and sugarcane have all been recorded with asphalt barriers around 60cm deep (Sumner and Gilfillan, 1971).

In Taiwan, paddy rice (which has a very high water requirement) was grown in a sand soil (where very poor growth would be expected). With barriers placed at varying depths of 20cm to 60cm, yields were increased ten- to fourteen-fold.

Deep barriers of around 60cm may be best for larger plants such as sugarcane and Napier grass; however most vegetables might only need barriers at a depth of around 25cm to 50cm.

On smaller vegetable farms or gardens, heavy duty black plastic could be substituted for asphalt. On a small scale, black plastic could be placed at a depth of perhaps 25cm to 35cm, in a bowl or basin shape, of about 35cm or more in diameter, and a depth of a quarter to half of the diameter, to hold water. Gaps of about 5cm could be left between each "bowl", so that excess water could drain away between them. Around four bowls per square metre should work well. In long beds, plastic could form a gutter or gutters, with a drip system above. Other "bowls" could be gourds or calabashes cut in half, large bamboo culms split in half, half coconut shells and plastic bowls, depending on availability and cost.

A 1.5 to 4 litre plastic bottle or tin with holes in the base (or a dripper) and an open top for filling with a watering can or plastic bucket, could be partly buried directly above the bowl so that the water (and perhaps dissolved fertilizer) flows through the soil and down into the bowl. Some high quality vermicompost or fertilizer could be placed so that the water flows from above and through it to the bowl. Plant roots should then proliferate in the bowl, where the water and nutrients are concentrated. Some plants which require excellent drainage (such as lettuce) may not grow so well in this system, suffering from waterlogging and possible root rot diseases, while others that require a lot of water should grow much better.

Another possibly better option would be to use multiple sheets of newspaper (biodegradable) to form the bowls. The newspaper will hold the water, but allow it to pass through slowly, minimising stagnant waterlogging problems. One litre of water takes around 6 to 8 hours to seep through twenty sheets of newspaper, which should be fast enough to avoid waterlogging problems, but slow enough for the plants to use most of the water. If desired, this might be slowed down further by using a watering can to apply an emulsion of vegetable oil and water, or a clay slurry, on to a bowl of approximately ten sheets of newspaper, and then placing another ten or so sheets on top. Gaps should be left between the bowls to allow excess water to drain and for roots to gain access to deeper soil. I am uncertain how long the newspaper would last in the soil, but it could be placed at the beginning of the dry season, and should last long enough to produce a dry season crop, and possibly deteriorate through the wet season. Newspaper is often used at the base of no-dig gardens, and usually lasts for a few months at least. Newspaper "bowls" may therefore require annual replacement.

Impermeable water barriers should increase productivity in otherwise dry sandy soils by 35%, and possibly a lot more. Slowly permeable barriers such as multiple sheets of newspaper could be even better.

Water barriers plus drip irrigation will provide very economical use of water (a plastic bottle or tin with holes in the base constitutes a low-tech form of drip irrigation). Drip irrigation has been shown to cut water usage by 30-40% while increasing yields 20-90%.

Clear plastic/polythene sheet and polypropylene "garden fleece"

Plants which are covered and protected by glass or clear polythene in greenhouses can be grown year-round, with annual productivity commonly two to three times higher than in open fields (and even further enhanced with carbon dioxide enrichment), (Atwell *et al.* 1999).

Individual tree shelters using three or four stakes and a sheath of clear plastic are commonly used in the U. K. and in Australia. The height of the plastic is typically about 60cm to 120cm. The shelter provides a "greenhouse effect", and protection from browsing animals such as rabbits. The results are more pronounced in cold climates, with young oak trees in the U. K. that are sheltered growing 5 times taller and 6.2 times the stem volume in the first three years, compared with trees that are not sheltered (Tuley 1985).

If little or no money is available, freely available reeds such as *Phragmites* could be used as stakes, and free plastic bags from grocery stores or supermarkets could be used to shelter individual vegetable plants. The plastic bags would need to have the bottoms cut out, and could be placed one on top of the other to make a higher shelter. Also, a painter's drop sheet may be a cheap source of polythene sheet.

For a vegetable bed of one metre by two metres, for example, a simple and cheap greenhouse (cold frame) can be made using six wooden stakes on the corners and middle of the length of the bed, with about 80cm sticking out above the ground. Clear plastic can then be attached to the stakes using a staple gun or drawing pins, forming a plastic wall (like an extra large tree shelter). Two more stakes evenly placed along the centre of the bed, around 1.2 metres high, provide the option of an additional sheet of plastic to be placed as a roof over the whole bed. This sheet is held in place either with tennis balls that have an X cut into them, holding the plastic onto the top of the stakes, or using sturdy removable clamps normally used to hold paper documents together. The cover is folded and tied out of the way or removed altogether in warm weather. During hotter times of the year, the plastic could be sprayed with a whitewash made of lime or gypsum (for cooling shade), or alternatively replace the plastic with non-woven polypropylene fleece.

A larger cheap tunnel-shaped greenhouse can be made with taller stakes and hoops of black polythene irrigation pipe. This should suit taller crops such as maize, and may make it possible to grow more tropical plants such as *Moringa oleifera* PKM 1, or PKM 2. A plastic underground water barrier, plus some form of plastic cover, should increase the types of vegetables that could be grown, for example sweet potatoes and kangkong.

Partial protection with polythene sheet or fleece shelters/mini greenhouses should provide yield increases of at least 50%.

Partly decomposed compost and CO2 enrichment

Partly decomposed compost gives off carbon dioxide, and carbon dioxide is heavier than air. If a garden bed has a wall of clear plastic of about 80cm high around it, and preferably a sheet of plastic over the top, partly decomposed compost could be used as mulch, and at least on days that are not windy, the CO2 near the ground should increase the growth of small vegetable plants. I do not know if this has been tested, and the compost could also give off harmful gases, but given the dramatic increases that can be achieved with CO2 enrichment, it is worth trying. “Growth responses to elevated CO2 can be spectacular, especially during early exponential growth” (Atwell et al. 1999).

Probably a 10% or more response could be expected from small young plants, and could get seedlings off to a good start.

Windbreaks

In windy places a windbreak can increase plant growth because transpiration losses are reduced and stomata remain open to take in carbon dioxide for photosynthesis and thus growth. The growing area should be within 8 to 10 heights of the windbreak, i.e. a 2 metre high windbreak would protect 16-20 metres or so. A windbreak of plants may compete with vegetables. This may be less of a problem if the windbreak is watered and fertilized, or there is a gap of a few metres (such as a road/path) between the windbreak and the vegetables. Depending on ultimate size, plants would typically be planted .8 to 1.5 metres apart.

Fleece

An instant and relatively cheap windbreak can be made using wooden stakes, with polypropylene non-woven fleece (also called frost protection blanket or horticultural or garden fleece) attached to the wooden stakes with staples or drawing pins, and takes up little space. This is cheaper than shade cloth or hessian, but also relatively flimsy and may be short-lived. Windbreaks that use palm fronds for example, or artificial materials, have the advantage that they do not cause problems of root competition as plants do, and take up less space.

Climbers

Some of the plants on the following lists will grow without any care, but most will grow better if they are at least mulched, and better again if given some water and fertilizer occasionally, and protection from wind.

Climbers can be grown on a support of stakes or steel posts and wire mesh, and take up little space. Many climbers grow faster than shrubs or trees, and may grow to more than two metres high in one or two growing seasons. Compared to shrubs and trees, their roots usually do not compete as aggressively with vegetables growing nearby for water and nutrients. A variety of climbers, flowering at different times, could be used to attract beneficial insects and birds. Some climbers that may be suitable include: *Delairea odorata* (syn. *Senecio mikanioides*), *Senecio tamoides/angulatus*. *Dipogon lignosus* (formerly *Dolichos lignosus* – produces edible beans, fodder, mulch and can be a green manure crop, and would warrant work to produce improved varieties), *Tecoma capensis* (orange flowered form, can be grown as a shrub or climber, attracts birds and provides habitat for chameleons), *Aloe ciliaris*, *Plumbago auriculata*, ivy pelargonium, *Teragonia decumbens*, *Kennedya nigricans, K. rubicunda.* The Australian *Kennedya* species could become weeds. *Delairea, Senecio* and *ivy pelargonium* may slow down or reduce the intensity of a fire. All these are likely to attract beneficial insects or birds (with the possible exception of ivy pelargonium), and *Dipogon* and *Kennedya* are nitrogen-fixing, and could provide some mulch and compost material. Young bean pods of *Dipogon* are reported to be edible, perhaps after cooking.

Hedges

These are slower to grow, but cheap in the long run and provide habitat value for beneficial wildlife. Plants can be grown in a single row of one species, but two rows, with shorter bushes on the windy side, and a wide mixture of species, should work best. A low windbreak of stakes and clear plastic or fleece approx. one metre high would help plants to get off to a good start. Some plants that may be suitable include:

South African plants:

Tarchonanthus, Metalasia muricata, Tecoma capensis, Plumbago auriculata, Polygala myrtifolia, Chrysanthemoides monilifera, Atriplex cinerea, Leonotus leonorus (L. ocymifolius), Dodonea viscosa, Crotalaria capensis, Leucospermum reflexum, Cyclopia spp., Calobota cytisoides, Passerina corymbosa, P. ericoides.

Animal and human barriers: *Aloe arborescens* (may also stop fires), *Lycium ferocissimum*.

Exotic plants:

Bana grass (Napier grass, elephant grass, *Pennisetum purpureum*), *Westringia fruticosa, Lagunaria patersonia, Coprosma repens* (probable weed), *Rhaphiolepis* x 'Delacourii' (possible weed), *Hakea salicifolia* (formerly *Hakea saligna*, and apparently not a weed in South Africa).

Tree Lucerne/Tagasaste (probable weed): Weed potential would be minimised if trimmed before seedpods mature. This plant should form an excellent windbreak and can be clipped to the desired shape. It fixes nitrogen, provides animal fodder, nectar for bees/honey and excellent mulch. The deep roots (to ten metres or more) make it drought tolerant and bring nutrients to the surface. It may cause problems competing with vegetables growing nearby.

Windbreaks are likely to increase yield by 10-50% or more, and possibly more than 100% - in one case in Tunisia (similar latitude to the Cape Flats), tomatoes increased by 125%, see http://www.idrc.ca/en/ev-27155-201-1-DO_TOPIC.html.

Increasing biodiversity/attracting beneficial insects and birds

Growing a wide variety of preferably indigenous plants can attract beneficial birds, beneficial insects which eat insect pests, and bees for pollination and honey production. One or preferably more beds, evenly dispersed through the area, could be dedicated to growing a range of indigenous plants to attract beneficial wildlife.

Allan Savory (1999) states that 90 percent of insects are beneficial to crops, and that "a single little brown bat can catch 600 or more mosquitoes in an hour, a colony of thirty could easily catch more than 30 000 insects in an evening's feeding". Hodges (2002), states that birds are able to deal with from 40 to 90 percent of problem insects. Dense bushes or hedges provide places for birds to nest, and nest boxes for birds and insect-eating bats can also be provided. Tall perches made of long dead branches provide places for birds to roost at night and perch in the day, including possibly owls and hawks to control rodents. Attracting insects also provides food for free-range poultry.

Some plants, such as Aloes which provide nectar for both birds and bees, should be given priority, as well as plants which produce both flowers and fruit, and even better if they do this repeatedly throughout the year. There should be flowers and nectar available at all times of the year, as well as water (e.g. birdbath, pond), and perhaps fruit, as a decoy from fruit trees.

South African plants:

"Daisies" in the Asteraceae and Aizoaceae are particularly useful for attracting beneficial insects. For example, *Hymenolepis parviflora* flowers in summer, and could be combined with *Euryops virgineus*, which flowers in winter, to attract beneficial insects (see www.plantzafrica.com).

More “daisies”: *Euryops* spp., *Senecio elegans, Tripteris* spp., *Chrysanthemoides monilifera, Dimorphotheca* spp., *Osteospermum* spp., *Cineraria saxifraga* (prefers some shade), *Athanasia dentata, Athanasia* spp., *Felicia* spp., *Helichrysum* spp., *Syncarpha* spp., *Drosanthemum* spp. See also those listed under the heading “Paths”.

Also: *Scabiosa africana, S. incisa, Lobostemon fruticosus, Peucedanum polyactinum, Limonium peregrinum, Eriocephalus africanus, Phylica ericoides, Coleonema spp., Buddleia salvifolia, B. auriculata, Agathosma* spp., (formerly *Barosma*), *Pseudoselago serrata, Salvia chamelaeagna, S. africana-lutea, Anchusa capensis, Crassula ovata, Crassula dejecta, Tulbaghia spp*. (flowers may attract some insects and the foliage may be a repellent), *Crotalaria capensis, C. agatiflora, Tephrosia* spp., *Diosma* spp, *Phyllica ericoides.*

Plants with red or orange tubular flowers generally attract birds which eat nectar and these birds usually eat insect pests as well. The following may be suitable:

Leonotis leonorus (syn**.** *Leonotus ocymifolius*), *Watsonia spp., Anapalina spp., Cyrtanthus ventricosus, Erica mammosa, E. bauera, E. cerinthoides, E. densifolia, Erica cruenta, Erica* spp., *Leucospermum reflexum, Cotyledon orbiculata* (poisonous leaves) *Aloe perfoliata, A. striata, A. maculata, Aloe* spp., *Chasmanthe aethiopica, Crocosmia* spp., *Kniphofia* spp.

Exotic plants

Particularly the daisy family again, and the Apiaceae.

Calendula (preferably not double-flowered varieties), *Phyla nodiflora* (syn. *Lippia nodiflora* - probable weed), *Salvia rutilans*, sunflowers, Jerusalem artichoke, *Limnanthes douglasii, Tanacetum vulgare* (one of the best for beneficial insects, e.g. hoverflies and lacewing larvae which control aphids), *Tanacetum spp, Chrysanthemum frutescens* and cultivars, dill, borage, comfrey (bees, compost, fodder, mulch), nasturtium, *Armeria maritima* (possible weed), *Aloe vera, Aeonium arboreum, Sedum spectabile, Sedum spp., Ajuga* spp., *Nepeta* spp., *Agastache cana, A. rugosa, Agastache* spp., *Thymus* spp., *Lavandula* spp., rosemary, *Anthemis tinctoria, Cosmos bipinnatus, C. sulphureus* (edible leaf tips), *Achillea* spp., *Coriandrum* spp., Chicory (possible weed), *Kalanchoe* spp. (*Bryophyllum* - probable weeds), *Tagetes* spp. (nematode control), *Hebe* spp. and cv.s, *Justicia californica* (possible weed), *Russelia equisetiformis* (should attract sunbirds), *Grevillea* spp. and hybrids (hybrids may be less likely to be weeds – *Grevilleas* attract bees and birds and flower repeatedly), *Melaleuca* spp. (including the former *Callistemon*, possible weeds), *Kunzea ambigua* (probable weed), *Leptospermum scoparium* (possible weed), *Zieria* spp. (possible weed), *Chamaelaucium uncinatum* (possible weed), *Thryptomene* spp. and cv.s (possible weed), *Correa* spp., lemon-scented verbena, buckwheat, *Ceanothus* spp. and hybrids, *Xerochrysum bracteatum* (*Helichrysum*, possible weed), Cape gooseberry (minor weed), *Dicliptera suberecta* (possible weed), yarrow, *Gaillardia, Zinnia,* Queen Anne’s Lace (possible weed), fennel (possible weed).

Paths

Paths could be left as bare soil, which would provide extra runoff water into the garden beds, but would also result in topsoil loss through wind and water erosion. Paths can be mulched, reducing erosion, if sufficient mulch is available. Alternatively, low-growing plants (e.g. groundcover daisies) could be grown to attract bees and other beneficial insects, and to produce mulch (e.g. subterranean clover, *Biserrula pelecinus*). One disadvantage would be that people who are barefoot may be stung by bees.

South African plants:

Arctotis stoechadifolia, Arctotis spp. (may harbour snails) *Disphyma crassifolium, Drosanthemum floribundum, Gazania* spp. (may harbour snails), *Arctotheca calendula* (perennial form), *Felicia* spp., *Carpobrotus* spp., *Aptenia cordifolia, Mesembryanthemum crystallinum* (edible leaves), *Tetragonia decumbens* (edible leaves), *Osteospermum fruticosa, Osteospermum* spp., *Dimorphotheca* spp., *Dimondia margaretae, Ursinia* spp., *Geranium incanum, Crassula anomala, Crassula* spp., *Cotula sericea, Othonna* spp., *Glottiphyllum longum, Ruschia* spp., *Delosperma* spp., *Cephalophyllum* spp., *Argyroderma* spp.

Exotic plants:

Erigeron karvinskianus (possible weed), *Phyla nodiflora* (syn. *Lippia* – probable weed), *Lobularia maritima* (Alyssum – white or cream flowered varieties), *Portulaca grandiflora* (possible weed), *Tetragonia tetragonoides* (edible leaves), *Trifolium subterraneum, Trifolium* spp., *Biserrula pelecinus, Matricaria recutita, Ajuga* spp., *Nepeta* spp., *Origanum* spp., *Chamaemelum nobile (Anthemis), Thymus* spp., *Scaevola* spp. (*probable weed).*

The benefits of increasing biodiversity are difficult to quantify. Monocultures are more likely to have a disease or pests go through the whole crop compared with a diversity of plants grown in rotation. Pests are usually reduced and pollination increases yield (for example, pumpkins, marrows, cucumbers), and plants which produce nectar provide an opportunity to produce honey.

Human urine

Human urine is usually sterile, is a free resource and has been used to grow vegetables with great success. A dilution of between 5% and 10% is normally used. See the base fact sheet: “The Ecosanres Programme”, and fact sheet 6 “Guidelines on the use of urine and faeces on crop production” at www.ecosanres.org/factsheets.htm.

Arborloos

The arborloo was invented by Peter Morgan in Zimbabwe and is best suited to places where the water table is not close to the surface. I do not know if it would have any application or be suitable on the Cape Flats, but it is an interesting idea. The arborloo is basically a pit toilet where about 30cm of topsoil is placed on top of the faeces when it is near full, and a fruit tree is planted on top. Other useful plants such as those that produce fodder or timber/fuelwood or mulch could also be grown.

An additional option would be to burn some wood on top of the faeces (and possibly bones), with a sheet of corrugated iron on top to reduce the oxygen (pyrolysis). Cans of water on top could be boiled or at least heated above 65 degrees centigrade or so, and then poured into the hole – the heat from the fire and hot water should destroy possible disease organisms. This could be called a “charborloo”. See www.ecosanres.org/factsheets.htm - fact sheet 13 “Toilets that make compost”.

Limited space - bag gardens and keyhole gardens

These are two ideas which have been promoted by an organisation in the U. K. and have been used in East Africa and Lesotho, and may be appropriate. See www.sendacow.org.uk. (on the bottom of the homepage).

Another way to grow vegetables/herbs in limited space is to stack plastic buckets or polystyrene foam boxes (with holes made in the base) alternately on top of each other. They can be stacked sloping against a wall for greater stability, and preferably in a position that gets sun for half the day or more.

Limited space - greenroofs and climbers

Roofs are a tough environment for plants with extreme light levels, wind, heat, dryness and cold. Only the toughest plants are likely to grow reasonably well. Some that could grow and produce something to eat include *Carpobrotus edulis*, *Tetragonia tetragonoides*, *Atriplex cinerea*, *Portulaca oleraceae* var. *sativa* (golden purslane), pitaya, *Chenopodium bonus-henricus* (Good King Henry), and some species of culinary herbs. Plants could be chosen that have other uses, e.g. nectar for honey, or to attract beneficial wildlife. Some possibilities include: *Aloe tenuior*, *A. vera*, *Aloe* spp., *Crassula* spp., *Sedum* spp., groundcover daisy spp.

A cheap option to grow plants on a sloping roof is to use potting mix or compost and some topsoil in a hessian bag or old pillowcase. The open end can be stapled or sown together and “X” shaped holes cut into the bag for planting. The bag should be positioned so that the longest side intercepts water flowing from the area of the roof above it when it rains. The bag is also placed near the lower end of the roof so that there is a large area of roof above acting as a water catchment. An old towel or blanket can be placed underneath the bag to soak up some of the drainage water, which is on top of a piece of plastic to protect the roof. Multiple bags can be used, and a ridge of clay, cement or polyurethane foam can be formed across the roof, sloping down to the bags, maximising the catchment area. A tin or plastic bottle with holes in it can be used on top of the bag to provide water and liquid fertilizer. Bags may need to be fixed in position on steep roofs.

Alternatively plants can be grown in the ground (where it is easier to water and fertilize them, and runoff from the roof can be used) and trained onto a support till they grow onto the roof. Some plants that may succeed include pumpkins, *Dipogon lignosus*, passionfruit (may attract rats), *Seschium edule*, *Actinidia*, grapevines and possibly melons. Foliage on roofs has a cooling effect in summer (from shade and transpiration), and may insulate against cold in winter. Other climbers worth growing but which may not reach the roof include beans and cucumbers. Fruit trees can be espaliered to take up less space, and dwarf varieties grown.

The website www.abodshelters.com/ shows an interesting design for relatively cheap housing, which would benefit from plants grown over the top of them on a wire mesh support.

Limited space – indoor sprouts, herbs and mushrooms

While these do not produce a lot of food, they can make an important contribution to nutrition.

Of the suggestions made in this article, adding organic matter to sandy soils, such as compost and biochar, is likely to be most cost effective, followed by clear plastic walls and covers.

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