



Encouraging diversity: Companions, covers and flower strips – a solution to many grower issues?

Increasingly it feels like South African growers of fresh fruit are being backed into a corner. The loss of active ingredients/chemicals for exports as a result of legislation such as the EU Green Deal, and the long time taken to firstly prove an active is effective and then have it registered is leading to a future where growers can either not produce fruits with the desired quality, or have to apply chemicals off-label. What if the solution is to increase the plant diversity in orchards, as part of a regenerative/sustainable strategy in commercial agriculture?

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SUBTROP

Commercial agriculture in South Africa is becoming increasingly challenging, including for growers of fresh fruits such as those of the Subtrop member associations. Several challenges are well-known, including threats of land expropriation, increasing costs, security on farms and issues at ports. Growers have to contend with these as well as the normal day-to-day challenges.

Besides these, there are other challenges: increasing numbers of audits, the EU Green Deal (especially the Farm-to-Fork strategy) and the challenges of having plant protection products that are registered on the target crop to control one or more pests or diseases. It seems regulators have identified these issues and put in legislation, but provided no clear means or solutions at the ground level to guide growers on a way forward. How do growers deal with having fewer plant protection products available while still catering to the demands of having to produce food that meets the requirements of discerning consumers?

Besides those issues already cited, annual feedback and queries from growers related to biological management also regularly surface, including how to improve soil health, how to manage and improve pollination, and how to address the problem of unwanted animals (bush-buck, snails and others) from damaging trees or picking fruits. Solutions to these tend to be limited to application of single products, but perhaps a more holistic

solution to these, and some others mentioned above, may be to increase the diversity of plant life in and around orchards.

Plant diversity means insect diversity (and soil diversity)

Life functions as communities, a concept which has been adopted into the terms microbiome (consisting of various microorganisms interacting synergistically) and macrobiome. Every plant and animal has at least one microbiome that interacts with it. In humans, microbiomes in the gastrointestinal tract and on the skin are indicative of health: a healthy diet fosters a healthy microbiome in the gastrointestinal tract and on the skin (Mendes and Raaijmakers, 2015). This thought has permeated consumer culture and is one reason why veganism is a popular diet option, and why fresh fruits such as avocados, mangoes and litchis are becoming increasingly popular diet choices.

In plants, there are microbiomes associated with the soil, roots, stem and branches, flowers and fruits. Plant microbiomes are highly variable and their structure is influenced by host genotype, soil characteristics and fertilisation, pathogen infection and pesticide application amongst others. Conversely, the composition of a plant root-associated microbiome can determine whether that plant is susceptible to infection by a pathogen.

Hence, transplanting soil that suppresses a pathogen causing a disease close to roots of a plant, to another area

where the pathogen is not suppressed, can help plants in the latter area recover. Similarly, plants struggling in one area might benefit from soil transplantation, with added compost and fertiliser, from plants prospering in another area. In these cases, soil transplantation transfers microbiome communities that have established in the soil (Mendes *et al.*, 2011; Mendes and Raaijmakers, 2015).

Commercial agriculture is usually oriented against promoting the establishment of microbiome communities. Deep ripping and tillage loosen soil and allow for root penetration of planted crops, but in the process disturb and destroy microbiome communities in the soil. Further along, weeds that sprout and emerge are treated with a herbicide based on the rationale that they compete for nutrients, space and water with planted crops. However, weeds can be used as indicators of soil health and are better suppressed through the planting of cover crops (see below).

Pests and diseases that occur are treated with fungicides and bactericides, but applications of these obviously also disturb and destroy microbiome communities. The result is a process that is very sterile; crops grow and mature in an environment where other plants and insects that they would have interacted with, have been killed.

To promote soil microbiome diversity, one has to add plants such as cover crops and flower strips into orchards. Cover crop introduction promotes soil microbial diversity which, in turn, suppresses soil-based pathogens (Kim *et al.*,



2020; Vukicevich *et al.*, 2015). Cover crop introduction also has potentially other benefits; in avocado orchard plots, the introduction of cover crops reduced thrip numbers and scale infestations, and improved yields (Nengovhela, 2020). There are also other benefits: cover crops stabilize the soil and allow for water infiltration, reducing runoff and erosion.

Flower strips have also been incorporated into orchards, based on the principles that a variety of pollinators (including honeybees) are needed for successful pollination, and that these pollinators need a variety of food resources throughout the year (Albrecht *et al.*, 2020; Muñoz *et al.*, 2021; Nowakowski and Pywell, 2016). As expected, the incorporation of flower strips also leads to an increase in insect predators (Albrecht *et al.*, 2021; Dong *et al.*, 2021; Muñoz *et al.*, 2021).

It is unclear, however, whether incorporating flower strips into an orchard would increase yields: a meta-analysis of several studies indicates no differences in yields between orchards with and without flower strips (Albrecht *et al.*, 2020) but a recent study in avocado orchards found higher yields in plots near flower strips, probably through promoting pollination by pollinators other than managed honeybees (Muñoz *et al.*, 2021a).

It is important to bear in mind that the benefits of incorporating cover crops and flower strips are not necessarily seen within the first year of inclusion – the effects are only noticeable after 2-3 years (Albrecht *et al.*, 2020; Nowakowski and Pywell, 2016). Furthermore, flower strips need to be planted frequently within an orchard block; the pollination service provided decreases by more than 50% 10 m from a flower strip (Albrecht *et al.*, 2020), and thus flower strips should be established at 10-15 m intervals from each other. However, there are more immediate benefits: the incorporation of both cover crops and flower strips means that growers have potential inter-row crops that could serve as alternative sources of income to help pay loans quicker, and their inclusion in orchards might mitigate against unwanted animals. As examples; bushbuck and monkeys might graze from cover crops instead of from leaves or fruits of trees, and snails would be attacked by predatory insects.

The incorporation of cover crops, flower strips and other beneficial plants

into orchards is a movement that is slowly gaining momentum. It is unlikely that the implementation of these will completely eliminate the need to apply fertilisers or plant protection products, but they should help reduce complete reliance on these. Brendon Rockey, a potato grower in the USA prominent on Youtube, has incorporated cover crops and flower strips into his fields. Over a period of 30 years he has eventually got to a point where any audits are easy to comply with.

A list of possible companions, covers and others

An article promoting the incorporation of cover crops and flower strips has little value if a list is not included. Growers simply do not have the time to review the many potential cover crops, find out which prefer full sunlight or are amenable to shade, which flower when (and can therefore double as plants in a flower strip), and which are invasive.

Table 1 lists possible cover crops along with those that could double as companion crops. The list includes pollen and nectar ratings, months when flowering occurs, as well as an indication whether the plant is an annual or perennial, if it is leguminous, and if it is invasive. Besides these are bottlebrushes, aloes and eucalypts which are alternative sources of food for pollinators. The table will be placed on the technical section of the various association websites (SAAGA, SAMGA and SALGA) and routinely updated.

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Table 1. List of potential cover crops with companions. Also listed are other plants that can occur in orchards. Plant lists sourced from Botha (2020), LCE (2021), Strassburg (2021) and Ziton (2021, 2021a). Pollen and nectar data as well as most flowering times from Jo-hannsmeyer (2016). Plants have been organised around flowering times. As an example: cowpea consists of five different coloured flowers (purple, pink, yellow, white – grey used as a substitute, and blue). The main flowering times are December and January, but flowers are present from September through to May. Although many plants may not be currently commercially available, commercial companies selling seeds (e.g. Mayford Seeds/Sakata Seed, Starke Ayres, AGT Cover Crops, etc.) will most certainly import if there is a demand.

Plant (species, common name)	Type (companion, cover)	Growth habit	Pollen, nectar rating*	Flowering times												Notes	Flowering period
				Summer			Autumn			Winter			Spring				
Sweet clover (<i>Melilotus officinalis</i>)	Cover - summer	Partial to full sun		J	F	M	A	M	J	J	A	S	O	N	D	Annual or biennial, legume, invasive	Summer
Red clover (<i>Trifolium pratense</i>)	Cover	Full sun	N0-2, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume, invasive	Summer
Cowpea (<i>Vigna unguiculata</i>)	Cover, possible companion (avo- cado)	Full sun	N0, EN0-3, P0	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume	Summer
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Caraway (<i>Carum carvi</i>)	Cover – winter	Partial to full sun		J	F	M	A	M	J	J	A	S	O	N	D	Biennial, invasive	Spring & Summer
Buckwheat (<i>Fagopyrum esculentum</i>)	Cover – sum- mer, possible companion (avocados)	Partial to full sun	N1-4, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Summer
Rye (<i>Secale cereale</i>)	Possible companion (avocado)	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Summer
Bergamot (<i>Citrus bergamia</i>)	Possible companion (fruit trees)	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Summer
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Sunn hemp (<i>Crotalaria juncea</i>)	Cover	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Perennial, legume, invasive	Summer
Lavender (<i>Lavandula angustifolia</i>)	Possible companion (fruit trees)	Full sun	N2-4, P0-1	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Spring & Summer
Comfrey (<i>Symphytum officinale</i>)	Possible companion (fruit trees)	Partial to full sun	N1-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Spring & Summer
				J	F	M	A	M	J	J	A	S	O	N	D		
Onion crops (<i>Allium</i> spp.)	Possible companion (fruit trees)	Full sun	N1-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Spring & Summer
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Groundnut (<i>Arachis hypogaea</i>)	Possible companion (avocado)	Full sun	N0-1, P0-1	J	F	M	A	M	J	J	A	S	O	N	D	Annual, perennial, invasive	Summer & Autumn
Birdsfoot trefoil (<i>Lotus corniculatus</i>)	Cover – summer	Full sun	N1-3, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, legume, invasive	Spring – Autumn
Lucerne (<i>Medicago sativa</i>)	Cover – summer	Partial to full sun	N0-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, legume	Spring – Autumn
Nasturtium (<i>Tropaeolum majus</i>)	Possible companion (fruit trees)	Partial to full sun	N0-2, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual, perennial, invasive	Spring – Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Phacelia (<i>Phacelia tanacetifolia</i>)	Cover – summer	Partial to full sun	N3-4, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Spring – Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
Borage (<i>Borago officinalis</i>)	Possible companion (fruit trees)	Partial to full sun	N1-3, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual, biennial, invasive	Winter - Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		



Plant (species, common name)	Type (companion, cover)	Growth habit	Pollen, nectar rating*	Flowering times												Notes	Flowering period
				Summer			Autumn			Winter			Spring				
Sunflower (<i>Helianthus annuus</i>)	Cover	Full sun	N0-3, P0-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Spring – Autumn
Fennel (<i>Foeniculum vulgare</i>)	Cover	Full sun	N1-3, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Spring - Autumn
Yarrow (<i>Achillea millefolium</i>)	Cover – winter	Full sun	N1-2, P0-3	J	F	M	A	M	J	J	A	S	O	N	D	Legume, invasive	Spring - Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Marjoram (<i>Origanum</i> spp.)	Possible companion (fruit trees)	Full sun	N2-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Summer & Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
Sorghum (<i>Sorghum bicolor</i>)	Cover	Full sun	N0, HD0- 1, P0-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Summer & Autumn
Marigold (<i>Tagetes erecta</i>)	Cover, possible companion (fruit trees)	Full to partial sun	N0-2, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Summer & Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
Brown mustard (<i>Brassica juncea</i>)	Cover – sum- mer, possible companion (fruit trees)	Partial to full sun	N1-2, P1-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Winter - Autumn
Spike speedwell (<i>Veronica spicata</i>)	Cover – winter	Partial to full sun	N1-3, P0-1	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Spring - Winter
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Lemon balm (<i>Melissa officinalis</i>)	Possible companion (fruit trees)	Partial to full sun	N0-2, P0-1	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Summer -Winter
Soybean (<i>Glycine max</i>)	Possible companion (avocado)	Partial to full sun	N0-2, P0-1	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume	Summer
Velvet bean (<i>Mucuna pruriens</i>)	Possible companion (avocado)	Full sun	N0-2?, P?	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, legume, invasive	Summer & Autumn
Barley (<i>Hordeum vulgare</i>)	Possible companion (avocado)	Partial to full sun		J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Summer/ Autumn & Winter/ Spring
Basil (<i>Ocimum basilicum</i>)	Cover, possible companion (avo- cado)	Partial to full sun	N1-3?, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Summer & Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Blackjack (<i>Bidens bipinnata</i> , <i>B. pilosa</i>)		Partial to full sun	N1-2, P1-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Summer & Autumn
Teff (<i>Eragrostis tef</i>)	Possible companion (avocado)	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Annual	Autumn & Spring
Cosmos (<i>Cosmos bipinnatus</i>)	Cover – winter	Partial to full sun	N2-3, P2-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Autumn
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Desmodium (<i>Desmodium intortum</i>)	Possible companion (avocado)	Partial to full sun		J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Autumn & Winter
Daffodil (<i>Narcissus pseudonarcissus</i>)	Possible companion (fruit trees)	Partial to full sun	N0-1, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Winter
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Violet (<i>Viola odorata</i>)	Possible companion (fruit trees)	Partial to full sun	N0-1, P?	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, invasive	Winter & Spring
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		



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Plant (species, common name)	Type (companion, cover)	Growth habit	Pollen, nectar rating*	Flowering times												Notes	Flowering period
				Summer			Autumn			Winter			Spring				
Broad bean (<i>Vicia faba</i>)	Possible companion (avocado)	Full sun	N0-2, EN0-1, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume	Winter & Spring
				J	F	M	A	M	J	J	A	S	O	N	D		
Lentil (<i>Lens esculenta</i>)	Cover – winter	Full sun	N, P	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume, invasive	Winter & Spring
Medicks (<i>Medicago</i> spp.)	Possible companion (avocado)	Partial to full sun	N1-3?, P0-2?	J	F	M	A	M	J	J	A	S	O	N	D	Annual, perennial, legume, invasive	Winter & Spring
Dill (<i>Anethum graveolens</i>)	Cover – summer	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Winter - Summer
				J	F	M	A	M	J	J	A	S	O	N	D		
Lupin (<i>Lupinus</i> spp.)	Possible companion (avocado)	Partial to full sun	N0?, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Perennial, legume, invasive	Winter & Spring
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
				J	F	M	A	M	J	J	A	S	O	N	D		
Canola (<i>Brassica napus</i>)	Cover – winter	Full sun	N2-4, P2-4	J	F	M	A	M	J	J	A	S	O	N	D	Annual, biennial	Winter & Spring
Vetch (<i>Vicia</i> spp.)	Possible companion (avocado)	Partial to full sun	N1-4, EN0-2, P-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual, legume, invasive	Winter & Spring
White mustard (<i>Sinapis alba</i>)	Cover – winter, possible com- panion (fruit trees)	Partial to full sun	N2-3, P2-3	J	F	M	A	M	J	J	A	S	O	N	D	Annual, invasive	Winter & Spring
Coriander (<i>Coriandrum sativum</i>)	Cover – sum- mer, possible companion (fruit trees)	Partial to full sun	N1-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Winter & Spring
Oats (<i>Avena sativa</i>)	Cover crop	Partial to full sun	N0, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Spring
Rocket (<i>Eruca sativa</i>)	Cover – winter	Partial to full sun	N2-3, P1-2	J	F	M	A	M	J	J	A	S	O	N	D	Annual	Spring
Wheat (<i>Triticum</i> spp.)	Possible companion (avocado)	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Annual	Spring
Dandelion (<i>Taraxacum officinale</i>)	Possible companion (fruit trees)	Partial to full sun	N2-3, P2-3	J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Spring
Garlic (<i>Allium sativum</i>)	Possible companion (fruit trees)	Full sun		J	F	M	A	M	J	J	A	S	O	N	D	Perennial	Spring
Onion (<i>Allium cepa</i>)	Possible companion (fruit trees)	Partial to full sun	N0-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D	Biennial or perennial	Spring & Summer
Clover (<i>Trifolium</i> spp.)	Cover crop	Partial to full sun														Annual, legume, invasive	
<i>T. burchellianum</i>			N2?, P2?	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. fragiferum</i>			N2-3, P1-2	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. repens</i>			N1-3, P1-3	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. vesiculosum</i>			N3?, P	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. subterraneum</i>			N2-3, P	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. resupinatum</i>			N1-3, P0-2	J	F	M	A	M	J	J	A	S	O	N	D		
<i>T. balansae</i>			N2?, P3?	J	F	M	A	M	J	J	A	S	O	N	D		
* Pollen and nectar rating guide: N = nectar, P = pollen, 0 = none available, 1 = poor/minor source, 2 = minor-medium source, 3 = medium-good source, 4 = very good/major source, EN = extrafloral nectar, HD = honeydew, PR = propolis																	