

# Evolving meanings of ‘principles’ in agronomic discourse

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## Abstract

The notion of principles, and the sense that they are different from but closely linked to practices, is deeply rooted in the agronomy literature. However, these terms are currently used by different authors to mean very different things. This paper explores these various uses and meanings. We argue that an understanding of the use of apparently innocuous, everyday words like principles and practices provides a valuable insight into on-going debates, contestation and politics about the future of agriculture and food. In the case of principles, it is important to understand the forms they take, by whom they are proclaimed and for what purpose(s). We find that while most alternative agricultures define themselves through a set of principles, these do not challenge or undermine the scientific principles that underpin mainstream agronomy. Further, we argue that to articulate and proclaim principles is to seek to exercise discursive power. Specifically, proclaiming principles or defining a favoured approach to agriculture by articulating a specific set of principles, is to exert authority, bolster legitimacy and claim a place in a crowded and contested marketplace.

## Keywords

Agronomy, alternative agriculture, regenerative agriculture, framing, narrative, conservation agriculture, organic

## Introduction

In his 1914 Presidential Address to the American Society of Agronomy, entitled ‘Fundamental Principles of Agronomy’, Charles Piper (1914) noted that while:

‘the phrase “principles of agriculture” [...] is one that has frequently been used by writers interested in the advancement of agriculture [...] Curiously enough no one seems ever to have pointed out just what is meant by a general or fundamental principle in agriculture. Nor has anyone enumerated as such those already known or accepted’ (p.227).

In fact, Piper somewhat overstated the case, as nearly twenty years earlier Voorhees (1895) had set out to ‘state in logical order the principles of scientific practice and to show the relation of these scientific facts to farm practice’, and provide ‘a safe guide to practical men in their farming operations’ (p.3). But be that as it may, Piper went on to identify 18 such principles or ‘fundamental generalisations’ of crop production (see Appendix Table 1A). His second principle – ‘Tillage tends to increase yield’ – illustrates the depth and clarity of his synthesis. Piper’s understanding that these were tentative and potentially contentious is also clear: ‘I must confess that doubt exists in my mind as to whether all of these generalizations can properly be called principles, and I shall not be surprised if there is wide divergence of judgment [...]’ (p.228).

The notion of principles, and the sense that they are different from, but closely linked to practices, is deeply rooted

in the agronomy literature. Indeed, the coupling of principles and practices occurs frequently in publication titles, from mainstream textbooks like *Field Crop Production (Agronomic Principles and Practices)* (Wilson and Myers, 1954) and *Agronomy: Principles and Practices* (Enghiad and Marquez, 2019), to publications promoting alternative agricultures like *Biodynamic Principles & Practices* (Biodynamic Association, 2018) and *Sustainable Agriculture Principles & Practices* (SAI Platform, 2021). Implied in all of these titles is a sense that principles come first; they are more general or fundamental, of a higher order.

But this implied commonality is deceptive, as the principles referred to in some titles share little if anything with those in others. For example, while Piper used principles to refer to fundamental generalisations, the principles being referred to by FAO under the title *Three Principles of Conservation Agriculture*, including ‘permanent soil organic cover (at least 30 percent) with crop residues and/or cover crops’<sup>1</sup>, seem to be of an entirely different order. Similarly, when IFOAM-Organics International describes ‘the four principles of organic agriculture’ as Health, Ecology, Fairness and Care,<sup>2</sup> and SAI Platform (2021)

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states that ‘Our principles define sustainable agriculture and what we believe the industry can achieve’ (p.2), they suggest still other understandings of principles.

Thus, while both principles and practices have been in common usage in the agronomy literature for well over a century, these terms are used by different authors to mean very different things. Further, to date little attention has been paid to the use and role of these terms in agricultural discourse: Migliorini and Wezel (2017), for example, compared and contrasted principles and practices across organic agriculture and agroecology. While they noted these were ‘divergent’, they left the varied meanings and discursive roles of both terms unexamined.

The roles of framing and narrative in development policy discourse are widely recognised (e.g., Apthorpe, 1996; Brock et al., 2001; Roe, 1991).<sup>3</sup> Problem framing, and the development of compelling narratives, are strategic activities that ‘aim to create necessities for (specific) policy intervention’ (Leipold and Winkel, 2016: 36). Their utility rests in their ability to legitimise and/or delegitimise particular problems and solutions. Indeed, at their most compelling they can create the illusion that there is only one viable course of action. Frames and narratives are constructed using a variety of linguistic features and rhetorical devices. For example, the use of metaphor played a critical role in framing the problems of invasive plants (e.g., Bach and Larson, 2017) and ‘superweeds’ (Bétrisey et al., 2022). The point is that words – when, how and by whom they are used, and the meanings and images they convey – are one key to understanding the politics of knowledge in any particular field. This is as true for individual words as for more complex assemblages like metaphors.

In this paper, we explore the changing ways that the words principles and practices are used in agricultural, and particularly agronomic discourse. In doing so we aim to strengthen the theoretical and empirical understanding of the politics of knowledge in agricultural research for development (see Sumberg, 2017; Sumberg and Thompson, 2012; Taylor et al., 2021). We argue that an understanding of the use of apparently innocuous, everyday words like principles and practices provides a valuable insight into on-going debates, contestation and politics about the future of agriculture and food. In the case of principles, it is important to understand the forms they take, by whom they are proclaimed and for what purpose(s).

Our contribution is two-fold. First, we note that while most alternative agricultures define themselves through a set of principles, in no case do their defining principles challenge the scientific principles that underpin mainstream agronomy. Second, in drawing attention to the different meanings and uses of principles, we argue that to articulate and proclaim principles is to exercise, or attempt to exercise, discursive power. Specifically, proclaiming principles or defining a favoured approach to agriculture by articulating a specific set of principles, is to exert authority, bolster legitimacy, claim a place and recruit followers in a crowded and contested marketplace. Since no new scientific or explanatory principles are on offer, differentiation and legitimacy depends on the elevation of preferred practices to

principles, and/or the projection of normative (i.e., value and vision) principles.

We are acutely aware that at a time when agriculture faces significant challenges on multiple fronts – with climate change being a prime example – focusing on the use and meanings of everyday words like principles and practices leaves us open to the charge of being pedants, lost in the semantic undergrowth. However, it is precisely in the semantic undergrowth that the struggles over the future of farming and food system transformation are, to a significant extent, now being played out.

The paper proceeds as follows. The next section explores different dimensions of the notion of principles in agronomy texts using a scheme with three main types of principles: Explanatory, Directive and Normative. The focus of the next section is the phenomenon of common agronomic practices being proclaimed as the principles of alternative agricultures. The final section summarises and concludes with a plea for greater understanding and acknowledgement of the role of proclaimed principles in debates on farming and food futures.

## Principles

The Oxford English Dictionary (OED) provides a number of relevant entries for the word principle (Box 1). With entries 3c and 8a, principles are seen to emerge from, reflect or articulate settled understandings of the workings of either the natural world, or of a particular field of study. In contrast, entries 3a and 4a cast principles as rules, laws, truths, beliefs, propositions or assumptions that are meant to guide action or practice.

### Box 1. Relevant OED entries for ‘principle’

#### Principle\*

3a. ‘A fundamental truth or proposition on which others depend; a general statement or tenet forming the (or a) basis of a system of belief, etc.; a primary assumption forming the basis of a chain of reasoning.’

3c. ‘Science. A general or inclusive statement about an aspect of the natural world that has numerous special applications or is applicable in a wide variety of cases.’

4a. ‘A general law or rule adopted or professed as a guide to action; a settled ground or basis of conduct or practice; a fundamental motive or reason for action, esp. one consciously recognized and followed.’

8a. ‘In plural. The introductory or elementary aspects of a field of study; rudiments.’

\*principle, n. OED Online. December 2022. Oxford University Press. <https://www.oed.com/view/Entry/151459?rskey=nj5HK8&result=1&isAdvanced=false> (accessed January 22, 2023).

Given these different meanings, it should not be surprising that principle is used in a variety of ways in the agronomy literature. Table 1 provides examples of three types of principles, and their relevant sub-types, commonly encountered in this literature. We label these Explanatory, Directive and Normative principles.

**Table 1.** Types and examples of principles in the agronomy literature.

Principle Type	Sub-type	Example	OED sense	Context & reference
Explanatory	—	‘Vegetative vigor and reproductive vigor are mutually antagonistic’	3c & 8a	General (Piper, 1914)
	—	‘Yield and the quality of products from crops are strongly linked to the supply of nutrients’	3c & 8a	General (Black and Batten, 2003)
Directive	Should do	‘Keep the soil surface covered’	4a	Regenerative agriculture (groundswell.org)
	Should do	‘Do everything reasonably possible to build internal strengths into the agricultural ecosystem’	4a	Ecological agriculture (Magdoff, 2007)
	Must do	‘Crop rotations’	4a	Conservation agriculture (Hobbs et al., 2008; FAO, 2016)
	Don’t do	‘to minimize the use of non-renewable resources and off-farm inputs’	4a	Organic agriculture (The Soil Association, 2023)
	Don’t do	‘to exclude the use of soluble mineral fertilisers’	4a	Organic agriculture (The Soil Association, 2023)
Normative	Vision	‘an agricultural sector that ensures land use is appropriate given the characteristics of the terrain, maintains soil fertility and health, prevents damage and provides benefits to the surrounding environment, and ensures the land acts a significant greenhouse gas sink’	4a	Sustainable agriculture (SAI Platform, 2021)
	Value	‘Fairness’	3a & 4a	Agroecology (agroecology-europe.org)

**Explanatory principles**

Mainstream textbooks and monographs, reflecting OED 3c and 8a (Table 1), have generally used principle to suggest a synthesis or explanation, reflecting settled or current understandings, of some aspect of the biological, ecological, chemical, and physical processes underlying the field of agronomy. Such principles seek to create or enlarge understanding rather than directly guide action or practice – indeed, they offer nothing in the way of recommendations or guidelines for situated practice.

For example, Voorhees’ (1895) book *First Principles of Agriculture* is very much in line with OED 8a. Each chapter deals with a ‘branch’ of the ‘various sciences in their relation to agriculture’ (including: Ch 1. The constituents of plants, Ch 2. Origin and formation of soil, Ch 3. Composition of soil, Ch 10. Rotation of crops). More recently, Azam-Ali and Squire (2002) introduced *The Principles of Tropical Agronomy* saying the book:

‘is concerned with the principles by which crop management can influence how plants use environmental resources. It deals with the biological processes that operate in the links between management, the physical environment and agricultural vegetation. It also seeks to identify general principles that operate across tropical species, cropping systems and environments’ (p.vii).

In other works, the presentation of principle(s) is sometimes organised around key aspects or steps in crop production, with, for example, Somasundaram and Mohamed Amanullah (2016) providing chapters entitled Tillage and Tith, Seeds and Sowing, Plant Population and Crop Geometry, Weeds, and Irrigation. Similarly, Pratley (2003) included chapters on Managing the Soil, Crop

Nutrition, Smart Rotations, Crop Establishment and Management, Weed Management, Pest Disease Management and Irrigation Management.

Regardless of how they are organised, the principles in these texts are elucidated based on the published scientific literature, and/or presented as a synthesis of extant evidence. In this sense, they represent the ‘state of the art’ at the time of writing. It must be acknowledged, however, that all such reviews and syntheses are potentially affected by selectivity and bias (Haddaway et al., 2015). Further, even in established fields of study there can be new, ambiguous and/or contested evidence, leaving room for interpretation and individual emphasis. No two reviews of a field will articulate exactly the same principles in the same way, even if they are written concurrently.

In addition to explanation and education, framing a field like agronomy, crop production or crop ecology in terms of principles can be seen as a discursive strategy by an author to establish her/his authority. Terms like fundamental principle, basic principle and core principle suggest solidity and certainty. Similarly, to be considered a ‘principled’ person or organisation, or one who takes an unpopular position ‘on principle’, is to be placed on a pedestal, and acknowledged as deserving of respect and attention. In this sense, highlighting or focusing on principles adds gravitas, and allows an author greater scope to impose her/his vision on a field.

**Directive principles**

In contrast to the mainstream agricultural literature, texts describing or promoting ‘alternative’ agricultures, generally use principle in the sense of OED entries 3a and 4a, as rules, laws, truths, beliefs, propositions or assumptions that guide,

or should guide, action. Such principles generally take one of three forms. Some, including the proclaimed principle of regenerative agriculture – ‘keep living roots in the soil’<sup>4</sup> – reflects an intention or aspiration, but how this might be done in any specific context is not specified. We refer to these as ‘should do’ principles: if you want your farming to be regenerative, you should try to keep living roots in the soil (but how you do it is up to you). Others, such as the Conservation Agriculture (CA) principle of ‘**Species diversification** through varied crop sequences and associations involving at least three different crop species’ (FAO, 2022), are centred on a particular agronomic practice – in this case, one that is obligatory (i.e., without ‘crop sequences and associations involving at least three different crop species’ you are not practicing CA). We refer to these as ‘must do’ principles (but see Kirkegaard et al. (2014) on the necessity of a pragmatic and flexible approach by Australian farmers to the adaptation and application of CA principles, due to diverse biophysical and socio-economic contexts). In still other cases, the opposite approach is taken, with principles identifying practices that are forbidden. Obvious examples are organic agriculture’s prohibition on the use of soluble mineral fertilisers, pesticides and genetically modified organisms (GMOs) (The Soil Association, 2023: 9). We refer to these as ‘don’t do’ principles, and in the case of organic agriculture they are enshrined in law (i.e., don’t use GMOs if you want to be – or are already – certified as organic).

In addition to guiding action, in some cases, a set or combination of directive principles is used to define a particular alternative agriculture or approach to farming. One example is CA, which FAO (2022) states is a ‘concept’:

‘based on three interlinked principles adapted to reflect local conditions and needs: by three must-do principles: **Minimum mechanical soil disturbance** (i.e., no/zero tillage) through direct seed and/or fertilizer placement [...] **Permanent soil organic cover** (at least 30 percent) with crop residues and/or cover crops [...] **Species diversification** through varied crop sequences and associations involving at least three different crop species [...]’ (p.2).

Unilever (2021) identifies four ‘overarching principles’ of regenerative agriculture and more detailed principles under headings Soils, Water, Climate, Biodiversity, and Livelihoods. All are directive or ‘do’ principles. For example, the principles under Soils are: ‘Keep living roots in the ground at all times; Apply zero-till or conservation till practices; Prevent erosion through e.g., cover cropping, mulching, terracing; Apply crop rotations with both shallow and deep rooting crops’. While the Unilever documents states that ‘The most appropriate regenerative practices are likely to be region, climate and crop specific’, it also suggests that ‘changing to a regenerative focus is likely to include, for instance, improving crop rotations, adoption of cover cropping, composting, mulching and conservation tillage practices.’ A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE, 2019) proposes 13

‘agroecological principles’ (also referred to as ‘principles of agroecology’), that are cross-referenced to FAO’s 10 ‘elements’ of agroecology (Barrios et al., 2020; FAO, 2018).<sup>5</sup> All 13 are directive, and they all begin with action words including ‘preferentially use’, ‘ensure’, ‘build’, ‘enhance’, ‘support’, ‘encourage’ and ‘diversify’. For example, Principle 2 is ‘Input reduction. Reduce or eliminate dependency on purchased inputs and increase self-sufficiency’, while Principle 3 is ‘Soil health. Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and enhancing soil biological activity.’

The discursive implications of directive principles are a major concern of this paper, and we will return to these later. But here we must be very clear: in no sense do these principles or the systems or approaches to agriculture that they define, represent alternative, competing or mutually-exclusive agronomic knowledge systems. Specifically, nothing in the alternative agriculture literature contradicts or rejects the mainstream presentation of, for example, the principles of crop production, soil science or crop ecology.

### *Normative principles*

We use the term normative to refer to a value judgment about the desirable state of something, in this case, agriculture. Reflecting OED 3a and 4a (Table 1), normative principles are thus beliefs, assumptions or values, sometimes consolidated into visions, that at a high level, guide (or should guide) action.

Within the mainstream agronomy literature, with its strong focus on Explanatory principles, aside from a nod toward sustainability, there is generally little explicit reference to values or visions. On the other hand, there is a strong implicit assumption that agriculture should be based on science, and should be productive, efficient and profitable, while minimising negative spillover effects on the environment.

In contrast, in the alternative agriculture literature normative principles are much more likely to be explicit, actively proclaimed and highlighted. For example, IFOAM (nd) indicates that a principle of organic agriculture is that it ‘should be based on living ecological systems and cycles, work with them, emulate them and help sustain them’ (p.2). Similarly, SAI Platform (2021) states that a principle of sustainable agriculture is ‘an agricultural sector that ensures land use is appropriate given the characteristics of the terrain, maintains soil fertility and health, prevents damage and provides benefits to the surrounding environment, and ensures the land acts a significant greenhouse gas sink’ (p.4). Magdoff (2007) writes that a principle of ‘ecological agriculture’ is to ‘do everything reasonably possible to build internal strengths into the agricultural ecosystem’ (p.111). A final example comes from the report of the High Level Panel of Experts on Food Security and Nutrition (HLPE, 2019). Within its ‘consolidated set of 13 agroecological principles’, under the heading ‘Secure social equity/responsibility’, it lists:

'10. **Fairness.** Support dignified and robust livelihoods for all actors engaged in food systems, especially small-scale food producers, based on fair trade, fair employment and fair treatment of intellectual property rights' (Table 1, p.41)

## Practices and their elevation to principles

For most of the history of agriculture, practice evolved with no reference to principles (or to theory); rather, trial-and-error, experience and precedent were the key factors informing farming practice. This began to change in the nineteenth century, with advances in the fields of chemistry and biology that laid the basis for 'scientific farming', and which ushered in a more dynamic interplay between evidence-based principles and practice. This new dynamic had important implications for agriculture: as Davenport noted, 'It is only when a subject has reached the scientific stage that it becomes teachable through the elucidation of the principles involved' (Davenport, 1912: 49).

As highlighted above, explanatory or scientific principles themselves provide little direct guidance as to what should be done in specific circumstances or contexts. Indeed, depending on objectives, resource availability, the policy environment and so on, the same principle could lead to a variety of very different, but equally appropriate, farm practices. It is through applied agronomy, farmers' experiments, agricultural extension and farm advisors that situated practice, informed implicitly or explicitly by principles, emerge.

Conceptually, within a scientific agriculture framing, the process by which a principle might inform farming practice starts with an 'intention' which represents the logical and practical extension of the particular principle. For example, with the principle 'yield and the quality of products from crops are strongly linked to the supply of nutrients', the logical agronomic intention is to assure the crop has adequate nutrition. In general terms, an intention such as this could potentially be achieved in a number of ways, including the application of synthetic fertiliser and/or manure, the incorporation of a green manure crop or compost, or leaving the land fallow. And in turn, each of these alternatives could then be implemented or operationalised in various ways.

In modern agricultural discourse, the term practice(s) is used in different ways, and at different levels of specification. For example, 'green manure' might be referred to as a practice. However, as with the fertiliser example above, it provides no real sense of what actions need to be taken. Without further information, green manure – or cover crop, or crop rotation – is little more than a placeholder, a practice in name only (PINO).

Nevertheless, the Internet abounds with websites and handbooks proclaiming 'good agricultural practices (GAPs)' or 'best management practices (BMPs)'. The claim is that GAPs and BMPs are designed to boost production and efficient use of inputs, thus contributing both to increased yields and minimising negative effects on the environment. Defining 'good' or 'best' practices for

different crops and cropping systems is a major focus of adaptive agronomic research. As what is 'best' can always be a matter of debate and refinement, some authors have opted to talk of 'better' management practices (IIED et al., 2004; Jelsma et al., 2019). The GLOBALG.A.P.<sup>6</sup> goes a step further to provide an independent certification scheme for good agricultural practice to set consumers' minds at rest in relation to product safety (notably pesticide residues), health, welfare and safety of farm workers and animals, and environmental impact.

With the rise of competing versions of alternative agriculture, we observe that what in the mainstream literature would be considered as practices (or more appropriately PINOs) are now being proclaimed as, or elevated to, the level of 'principles'. The question is, what does this elevation of PINOs to principles represent?

We have already ruled out the idea that it suggests a rejection of (or even a challenge to) the explanatory principles offered in the mainstream literature such as the principles of crop science, crop ecology, soil science etc. Nothing in the literature on agroecology, organic farming, regenerative agriculture, conservation agriculture, or SRI suggests a rejection of the mainstream explanatory principles. The fact that many alternative agricultures choose to define themselves by a selection of Directive principles (sometimes combined with Normative principles) only reinforces this point.

A more compelling explanation can be found in the imperative faced by the promoters of alternative agricultures to carve out space in an already crowded marketplace. To have any chance of gaining traction (and funding), every new or emerging alternative agriculture must set itself apart by building an identity and a brand. Differentiation from other alternative agricultures is just as important as differentiation from mainstream agriculture. The way the term 'conventional agriculture' has been weaponised by some promoters of alternative agricultures is a good example of differentiation at work (Sumberg and Giller, 2022). We suggest that articulating a limited set of simple, defining principles can be a very important part of this process. And since the explanatory or scientific principles are not being challenged, re-framing PINOs as principles is one obvious alternative.

But differentiation by proclaiming PINOs to be principles is only part of the story. As suggested earlier, the term principle(s) carries significant discursive weight. Proclaiming a set of Directive and/or Normative principles is a means of claiming legitimacy, authority and power. In effect, this is not too dissimilar to what authors of mainstream 'principles of agronomy' – type works have done over decades. But while those promoting alternative agricultures and those writing mainstream textbooks both use the same term – principles – what they have in mind could not be more different.

## Discussion and conclusions

We have established that in both general usage and in the agronomic literature the word principle(s) is used in a

variety of ways to convey different meanings and achieve different ends.

But across these different meanings, articulating or proclaiming principles is fundamentally an act of framing. We have argued that Explanatory principles are used primarily to frame a discipline or field of study (e.g., agronomy, soil science or crop ecology etc), while Directive and Normative principles are used to frame alternative agricultures (e.g., organic, regenerative or CA). In all cases, framing through the articulation of principles is an intentional attempt to exert influence, and potentially affect change (e.g., in the case of a field of study, how it is understood, or the direction of its research agenda; in the case of an alternative agriculture, how it is perceived by farmers, the public and/or policy makers).

The Directive principles that are central to the presentation and representation of alternative agricultures do not challenge or undermine the Explanatory principles that underpin the science of agronomy. Indeed, in most cases Directive principles of the ‘should do’ and ‘must do’ subtypes are in most cases well-known practices (or better, PINOs) that have been re-labelled or ‘upgraded’. In some cases, they are also packaged up with one or more normative – i.e., value and/or vision – principles.

Our explanation for the penchant for proclaiming principles within the alternative agriculture literature is that deeply embedded in the core of the word principle(s), well beneath the different shades of meaning and types of principles we have highlighted, is an implicit sense of truth, authority, respectability and legitimacy. In other words, the word principle is politically charged: it has very significant inherent strength and power. As such, it is an ideal framing element.

In practical terms, the need to raise funds, attract media attention, and be taken seriously in corporate boardrooms and policy fora demands a name, an identity, a brand. Being able to articulate a simple, compelling set of principles, and wrapping one’s preferred alternative agriculture in a narrative cloak woven from them, is essential to establish such an identity.

We make no value judgements either on the motivation to proclaim principles or on the principles themselves. Our conclusion is more straight forward. Any and every proclamation of defining principles for an agricultural system, an alternative agriculture or a food system must be seen and understood for what it is – a political act. If that simple fact could be widely acknowledged and internalised, there would be greater potential for fruitful discussions about farming and food futures.


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#### Notes

1. <https://www.fao.org/conservation-agriculture/en/> (accessed 6 September 2023)
2. <https://www.ifoam.bio/why-organic/shaping-agriculture/four-principles-organic> (accessed 6 September 2023)
3. There is now a large body of work that concerns itself with discourse, including framing and narrative, in the fields of agriculture and food systems. To cite just a few selected examples, Constance et al. (2018) analyse contested discourses in the agrifood system; Kelinsky-Jones et al. (2023) explore how discourse could be used to support a transition toward a more equitable and sustainable food system; McCaig et al. (2023) analyse farmers’ discourse in relation to the Internet of Things; and Erjavec and Erjavec (2015) analysed European Union documents for insights into the ‘greening’ of the Common Agricultural Policy.
4. <https://groundswellag.com/principles-of-regenerative-agriculture/> (accessed 6 September 2023)
5. Papers in a recent Special Issue of this journal interrogate some of these principles (see Falconnier et al., 2023; Wood, 2023)
6. <https://www.globalgap.org/> (accessed 6 September 2023)

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## Appendix

**Table 1A.** Piper's 18 principles or 'fundamental generalisations' of crop production (Piper, 1914).

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1. Every crop plant has a definite range of adaptations or reactions as regards climate temperature, moisture, light) and soil (moisture, texture, biology, chemical content).
  2. Tillage tends to increase yields.
  3. Shallow tillage conserves soil moisture.
  4. Rate of seeding or distance of spacing affects yield.
  5. Depth of planting affects stand and therefore may affect yield.
  6. Time of seeding affects yield.
  7. Quality of seed affects yield.
  8. Rotative cropping tends to increase or to maintain yields. Single cropping tends to reduce yields.
  9. Mixed seedings tend to increase yields.
  10. Fertilisers (nearly all common substances) tend to increase yields.
  11. The nitrogen content of the soil is most cheaply maintained by keeping up the supply of humus and especially by growing legumes, which alone of crop plants can utilise atmospheric nitrogen.
  12. Productivity is approximately maintained by feeding crops to animals and returning the manure to the soil.
  13. Selecting the best plants tends to improve the breed.
  14. Hybridisation tends to stimulate vigour.
  15. Plants introduced from their original to a new and similar environment often tend to become aggressive.
  16. Thinning buds by pruning or otherwise tends to increase the size of the remaining resultant flowers and fruits.
  17. Vegetative vigour and reproductive vigour are mutually antagonistic.
  18. Dwarfing of perennial plants may be secured by budding or grafting on stocks not wholly congenial.
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