Supplemental Information belonging to the manuscript "A review of crop husbandry and soil management practices using meta-analysis studies" by R. Rietra, M. Heinen, O. Oenema

Introduction

In the main text the following ten crop husbandry and soil management practices were considered:

1. Crop type & crop rotations, including intercropping, cover crops and perennial crops
2. Nutrient management
3. Irrigation + fertigation
4. (Controlled) Drainage
5. Tillage
6. Pest management
7. Weed management
8. Crop residue management & mulching
9. Mechanization & technology
10. Landscape management

For each of these practices main effects as reported in meta-analysis studies (plus a few reviews) were collected. Effects were divided into five so-called areas of interest (hereafter: aoi):

a) Agronomic effects (typically: yield, crop quality)
b) Soil quality & soil health
c) Resource use efficiency (mainly: water, nutrients)
d) Economic aspects
e) Environmental impacts (mainly: losses of greenhouse gases, and leaching)

These results were presented in the main text either as figures or tables. Here we present all data in the form of tables. As such, the tables of the main text are 1-to-1 copied here, and this gives a total overview of all data collected for these ten crop husbandry and soil management practices. All references provided can be found in the main text, and are not repeated here. Note that the data shown in the figures of the main text all refer to quantitative effect sizes; data provided here in the tables also include a few qualitative results as mentioned by the referenced studies.

1. Crop type & crop rotations, including intercropping, cover crops and perennial crops

Table 1. Cropping: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aoi	Management	Result
Crop type & crop rotation			
Relative yield cereals	a	Crop rotation vs none	+5.99% [a]
Yield effect cereals (Mg ha^{-1}), temperate sites	a	Legumes as pre-crops, no N fertilization	Broad leaved pre-crop (+1.4), oats (+1.5), cereal (2.2) [b]
	a	Legumes as pre-crops, 20-90 kg N ha^{-1} fertilization	Broad leaved pre-crop (+0.22), oats (+0.53), cereal (+0.7) [b]
	a	Legumes as pre-crops, 100-200 kg N ha^{-1} fertilization	Broad leaved pre-crop (-0.09), oats (+0.15), cereal (+1.47) [b]
Yield effect (Mg ha^{-1})	a	Legumes as pre-crops for rapeseed	+0.59 [b]
Yield effect (Mg ha^{-1})	a	Legumes as pre-crops for cereals on editerranean sites	Broad leaved pre-crop (+0.85), oats (+0.67), cereal (-0.16) [b]
Yield effect wheat (Mg ha^{-1})	a	Pre-crops vs wheat	Barley (+0.16 ns), oats (+0.53), canola (+0.8), mustard/canola (+0.57), flax/canola (+1.26), all legumes (+0.92), fallow (+1.12), break crops (+0.75) [c]
yield	a	Crop rotation vs continuous monoculture	+20% [z]
Soil organic C	b	Rotation versus monoculture	+20 g C m^2 yr^{-1} [d]
SMB, SMN, PLFA, dehydrogenase, metabolic quotient, protease activity, urease activity	b	Organic vs conventional	41, 51, 59, 74, ns, 84, 32% [ad]
Soil organic C, N (%)	b	Rotation vs monoculture	+3.6%C, +5.3% N [e]
Soil microbial C, N (%)	b	Rotation vs monoculture	+20.7%, 26.1% N [e]
Soil microbial diversity, richness (%)	b	Rotation vs monoculture	+3.36%, 15.11% [f]
Number of financial competitive over total number	d	Legumes as pre-crops	35 out of 53 [b]
% Increase in GHG	e	Rotation vs monoculture	+41% in CO_2 eq. per biomass, +46% in kg CO_2 eq. ha^{-1} yr^{-1} [g]
Intercropping			
Yield of OA*	a	Intercropping cereal and legume	+30% [h]
Relative yield	a	Intercropping cereal and legume	17% ns [i]
Yield as land use efficiency (LER)	a	Intercropping with and without maize	1.29, 1.16 [j]
N fertilizer equivalent ratio (NFER)	c	Intercropping with and without maize	1.33, 1.19 [j]
LER (yield), FNER	a, c	Intercropping maize and soybean vs mono	1.32 ± 0.02 [ac] 1.44 ± 0.03 [ac]
Density of specialist herbivorous insects, generalist herbivorous insects, predator insects	e	Diversified vs monoculture	-0.1, 0.05 ns, 0.24 [k]
Density herbivorous insects	e	Diversified vs monoculture	-60% [l]
Plant disease incidence	e	Intercropping cereals with faba bean vs no intercropping	-45% [u]

Cover crops			
Increase maize yield	a	Grass, legume or biculture winter cover crop vs fallow before maize in North America	0% ns, +37%, +21% [m]
Crop yield	a	Non-legume, leguminous cover crop vs fallow in winter	-3%, 6% [p]
Soil organic C	b	Cover crops versus fallow in winter	+0.32 Mg C ha^{-1} yr^{-1} [n]
Food crop yield Soil nitrate leaching	a e	non-legumes, legumes resp. as winter cover crops in Mediterranean vs no winter cover	-7%, 16% [ab] -53%, ns [ab]
SOM, SMB, soil N, soil water content, food crop damage, weed abundance, weed diversity	b	Winter cover crops in Mediterranean vs no winter cover	+9%, +41 -22, -13, ns, -27, -13% [ab]
SOC	b	cover crops	+6%[ae]
Soil infiltration rate	b	Cover crops vs none	34.8% [af]
cash crop yield soil aggregate stability, leaching, infiltration, MBN, soil BD, SOC, soil nitrogen, MBN, saturated hydraulic conductivity erosion, runoff, weed suppression	a b e	Cover crops vs none	6% [aa] 13, -62, 74, 27, -1, 9, ns, 26, 133% [aa] -75, -73, -45 [aa]
AM colonization cash crop roots	b	Cover crops versus fallow	+28.5% [o]
Nitrate leaching	e	Non-legume cover crop vs bare: in Nordic countries [16], global (17, 23], and irrigated systems [18]	-50% [p], -70% [q], -56% [w], -50% [r]
Ratio GHG's	e	Cover crops vs fallow	+46% CO_2, +49% N_2O [v],
N_2O emission in grain crops	e	Cover crops vs fallow, whole-year, only cover crops period	ns [x], -58% N_2O [x]
Ratio nematode abundance	e	Cover crops vs fallow	+29% [v]
Weed biomass	e	Cover crops vs none in corn-soybean rotation in U.S. Midwest	-75% [y]
Perennial crops			
Soil organic C	b	Cover crops vs bare between vines; olive trees	+0.78; 1.1 Mg C ha^{-1} yr^{-1} [s]
Soil organic C	b	Miscanthus vs control without	+0.40 Mg C ha^{-1} yr^{-1} [t]
% Decrease in GHG	e	Perennial vs monoculture	-168% in CO_2 eq. per biomass, -215% in kg CO_2 eq. ha^{-1} yr^{-1} [g]

[a] (Van den Putte, Govers, Diels, Gillijns, & Demuzere, 2010); [b] (Preissel, Reckling, Schläfke, & Zander, 2015) [c] (Angus et al., 2015); [d] (West & Post, 2002); [e] (McDaniel, Tiemann, & Grandy, 2014); [f] (Venter, Jacobs, & Hawkins, 2016); [g] (Sainju, 2016); [h] (Bedoussac et al., 2015); [i] (Y. Yu, Stomph, Makowski, Zhang, & van der Werf, 2016); [j] (C. Li et al., 2020); [k] (Dassou & Tixier, 2016); [l] (Tonhasca Jr & Byrne, 1994),[m] (Miguez & Bollero, 2005); [n] (Poeplau & Don, 2015); [o] (Timothy M. Bowles, Louise E. Jackson, Malina Loeher, & Timothy R. Cavagnaro, 2016); [p] (Valkama, Lemola, Känkänen, & Turtola, 2015); [q] (Tonitto, David, & Drinkwater, 2006); [r] (Quemada, Baranski, Nobel-de Lange, Vallejo, & Cooper, 2013); [s] (Vicente-Vicente, García-Ruiz, Francaviglia, Aguilera, & Smith, 2016); [t] (Poeplau & Don, 2014); [u] (C. Zhang et al., 2019) [v] (Daryanto, Wang, & Jacinthe, 2017); [w] (Thapa, Mirsky, & Tully, 2018); [x] (Han, Walter, & Drinkwater, 2017); [y](Nichols et al., 2020); [z] (J. Zhao et al., 2020); [aa] (J. Jian, Lester, Du, Reiter, & Stewart, 2020); [ab] (Shackelford, Kelsey, & Dicks, 2019); [ac] (Z. Xu et al., 2020); [ad] (Lori, Symnaczik, Mäder, De Deyn, & Gattinger, 2017); [ae] (Bai et al., 2019b); [af] (Basche & DeLonge, 2019).

* OA: organic agriculture

2. Nutrient management

Table 2. Nutrient management: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aio	Management	Result
Yield	a	Organic fertiliser in Mediterranean fruit orchards	Increase in 67% of studies ns [a]
Yield maize	a	Split application of N fertiliser vs early	-2.01% ns [b]
Yield	a	Fertilizer placement vs broadcast	+3.7% [o]
Yield	a	animal manure vs mineral: -in wheat, sugar beet, barley -in potatoes -in maize -all crops	 n.s. [c] +7% ±4.9 [c] +4% ±3.7 [c] ns [c]
Yield	a	Organic manure vs mineral: Wheat, Rice, Millet, Maize, barley	+27% [d]
Yield	a	Lime: CaO, $CaCO_3$, $Ca(OH_2$, $CaMg(CO_3)_2$	+13.2, 34.3, 29.2, 66.5% [e]
Yield, WP, NUE maize	a	Optimal vs non-optimal water and N supply	27.9%, 27.9%, 20.5% [i]
Increase N uptake	a	Urease, nitrification, and combined inhibitors	+24.1%, +10.5%, +47.6% [j]
% of studies: SOM	b	Organic fertiliser in Mediterranean fruit orchards	Increase in 87% of studies [a]
SOM, SMC*	b	Mineral N fertiliser Inorganic and organic N fertiliser	+12.08%,+15.05% [g] +7.6%,-9.5 [h]
SOM, SMC, EEA*	b	Organic manure vs mineral	+38% +51%, +39% [d]
Plant available water	b	Organic manure vs none	-10 to + 30% [m]
Maximum economic return	d	N fertilisation for sugar beet (UK)	105 kg N ha^{-1} [f]
Decrease of N loss	e	Urease, nitrification, and combined inhibitors	-32.9, -14.5, -37.6% [j]
NO emissions	e	Nitrification inhibitors	-80% [n]
Nitrate leaching, N_2O emission	e	Biochar	-13%, -38% [k]
N_2O emissions in grain crops	e	N fertiliser use according to recommendation vs higher N use	-55% [l]
NH_3 emissions	e	Urease inhibitor, manure acidification deep placement	- 24.3 to 68.7% -88.8 to 95.0%, -93.8 to 99.7% [p]
Survival time zoonotic pathogens	human	Animal manure vs none	+20% [q]
Yield upland crop Yield rice NH3 emission factor N_2O emission factor	a a e e	Partial and 100% substitution of mineral vs animal manure Manure N: upland, paddy soil Manure N: upland, paddy soil	+6.6, -9.6% [r] +3.3%, -4.1% [r] 0.56%, 0.17% [r] 11.1%. 6.5% [r]
Yield, pH, SWA*, SOC, TN, N_{av}, P_{av}, K_{av}, urease, sucrase, catalase, bateria, fungi, actinomyces, BD	a	Animal vs mineral fertilizer in China	+7.6, 3.3, 28.8, 17,7, 15.5, 16, 66.2, 19.1, 23.5, 18.3, 16.1, 60, 27.7, 38, -3.9% [t]
Relative yield increase of fruit crops	a	Application of N,P, or K fertilizer	78, 82.9, 82.4% [s]
CBH activity, C-acq activity, AP activity, BX activity, BG activity, AG activity, urease activity, MBC, PEO activity, OX activity, PHO activity, SOC, TN,	b	N enrichment in farmland	6.4, 9.1, 10.6, 11, 11.2, 12, 18.6, -9.5, -6.1, -7.9, -11.1, 7.6 15.3% [u]
Soil fungal diversity	b	Effect fertiliser:soil pH<6, soil pH>6	n.s, - H [v]
Soil C, N, P,	b	grazing intensity; High vs low	-4.3%, -9.9, +3.6%[w]

Corn yield	a	Sub-surface banded starter fertilizer application vs none in USA	+5.2%[x]
MBC, MBN β-1,4-glucosidase, dehydrogenase, urease, N-acetyl-β-glucosaminidase, alkaline phosphatase, acid phosphatase, sulfatase	b	Animal manure vs none	+88, +84%[y] 147, 114, 39, 112, 58, 104, 228%
NH_3 NO_x CH_4 CO_2 emissions	e	Slurry acidification vs raw	-69, -21, -86, -15% [z]

[a] (Morugán-Coronado, Linares, Gómez-López, Faz, & Zornoza, 2020); [b] (Fernandez, DeBruin, Messina, & Ciampitti, 2019); [c] (Hijbeek et al., 2017); [d] (G. Luo et al., 2018); [e] (Y. Li, Cui, Chang, & Zhang, 2019); [f] (Jaggard, Qi, & Armstrong, 2009); [g] (Geisseler & Scow, 2014); [h] *not used*; [i] (Y. Li, Z. Li, et al., 2019); [j] (Sha et al., 2020); [k] (Borchard et al., 2019); [l] (Han et al., 2017); [m] (Eden, Gerke, & Houot, 2017); [n] (Liu et al., 2017); [o] (Nkebiwe, Weinmann, Bar-Tal, & Müller, 2016); [p] (Ti, Xia, Chang, & Yan, 2019); [q] (Tran et al., 2020); [r] (X. Zhang et al., 2020); [s] (W. Li et al., 2020); [t] (Y. Du et al., 2020); [u] (S. Jian et al., 2016); [v] (Ye et al., 2020); [w] (M. He et al., 2020); [x] (Quinn, Lee, & Poffenbarger, 2020); [y] (S. Liu et al., 2020); [z] (Emmerling, Krein, & Junk, 2020).

*SOM: soil organic matter, SMB: soil microbial carbon, EEA: soil extracellular enzyme activity

3. Irrigation + fertigation

Table 3. Irrigation and fertigation: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest. DI = deficit irrigation, PRD = partial rootzone drying, FI = full irrigation, AI = aerated irrigation, NAI non-aerated irrigation, RDI = regulated deficit irrigation, CDI = conventional deficit irrigation, CI = conventional irrigation, OI = over-irrigation, UI = under-irrigation, OPTI = optimal irrigation.

Parameter	aoi	Management	Result
Yield	a	DI or PRD vs FI AI vs NAI RDI vs FI	-0.8 (standardized mean difference) [2] +30.4% [9]
Yield, WUE*	a,c	AI vs NAI RDI vs FI DI vs FI	+19.3%, +17.9% [4] -18.6 t ha^{-1}, +2.3 kg m^{-3} [5] -16.2%, +6.6% [8]
Yield, WP, NUE* of maize	a	OPTI vs OI OPTI vs UI	+26.4%, +26.8% and +17.0% [12] +25.3%, +25.1% and +19.8% [12]
Yield, WUE, NUE* citrus	a,c	OPTI vs OI OPTI vs UI	+12.4%, +27.6%, +12.9% [6] +20.2%, +3.7%, +20.2% [6]
Total soluble solids (fruit quality)	a	DI vs FI, PRD vs FI	+4.1% to +5% [1] significant improvement [5]
Vitamin C content fruits	a	RDI vs FI	significant improvement [5]
Water productivity	c	PRD vs CI CDI vs CI I vs non-I	+83% [7] +76% [7] +9.9% [9]
N_2O emission factor	e	I	+0.5% [3]
NH_3, N_2O emission, NO_3 leaching	e	I vs non-I	-9.3%, -42.3%, +36.1% [9]
Soil respiration, SOC*	b	I vs non-I	+9.7% [10], +1.27% ns [11]
Yield	a	Micro irrigation vs furrow irrigation	+36.7 (wheat), -21.4 (cotton) [a]
ET = Water use	c	Micro irrigation vs furrow irrigation	-22.7 (wheat), -36.8 (cotton) [a]
Yield	a	Optimized water management vs continuous flooding (rice; China)	<0 (severe soil water shortage) [b] +1 to +6% (mild water shortage) [b]
WUE, WP	c	Optimized water management vs continuous flooding (rice; China)	-40%, +34% [b]
GHG	e	Optimized water management vs continuous flooding (rice; China)	-37% (lower methane emission; lower energy consumption by irrigation system) [b]
WUE	c	Furrow irrigation vs rainfed	+14% (not significant) [c]
WUE	c	Pivot irrigation vs rainfed	+99% [c]
WUE	c	Subsurface drip irrigation vs rainfed	+147% [c]
NUE (NPFP; yield per unit input)	c	Irrigation vs no irrigation	+24% [d]
Yield	a	Non-continuous flooding vs continuous flooding (rice)	-3.6% [e]
CH4, N2O	e	Non-continuous flooding vs continuous flooding (rice)	-53%, +105% [e]
GWP (CH4 + N2O); idem, yield-scaled	e	Non-continuous flooding vs continuous flooding (rice)	-44%, -42% [e]
Yield	a	Optimal irrigation vs farmer irrigation (maize)	+6.5% [f]
ET = Water use	c	Optimal irrigation vs farmer irrigation (maize)	-10.9% [f]
WP	c	Optimal irrigation vs farmer irrigation (maize)	+18.1% [f]

[1] (Adu et al., 2019); [2] (Adu, Yawson, Armah, Asare, & Frimpong, 2018); [3] (Cayuela et al., 2016); [4] (Y.-D. Du et al., 2018); [5] (J. Lu, Shao, Cui, Wang, & Keabetswe, 2019); [6] (Qin, Assinck, Heinen, & Oenema, 2016); [7] (Sadras, 2008); [8] (L. Yu, Zhao, Gao, & Siddique, 2020); [9] (H. Zheng et al., 2019); [10] (L. Zhou et al., 2016); [11] (X. Zhou et al., 2016); [12] (Y. Li, Z. Li, et al., 2019); [a] (Fan, Wang, & Nan, 2018); [b] (He, Wang, & Cui, 2020); [c] (Mitchell-McCallister, Cano, & West, 2020); [d] (B.-Y. Liu et al., 2020); [e] (Jiang et al., 2019); [f] (H. Zheng et al., 2020).

* WUE: water use efficiency, WP: water productivity, NUE: nitrogen use efficiency, SOC: soil organic pool;

4. (Controlled) Drainage

Table 4. Controlled drainage: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest (see Table 1).

Parameter	aoi	Management	Result
Equal annual cost	d	Drainage vs none	9 to 37 $ ha^{-1} yr^{-1} [3]
CH_4 Emission from peat	e	Drainage vs none	-84% [1]
Drainage volume	e	Drainage vs none	-47% [2]; -17% to -85% [4]
N-load	e	Drainage vs none	-41% [3]; -18% to -85% [4]
Yield	a	Controlled drainage vs control	0.11 ns [a]
Drain volume	b	Controlled drainage vs control	-19.23% [a]
NO3-N concentration; NO3-N loss	b	Controlled drainage vs control	-19.07%; -36.11% [a]
NH4-N concentration; NH4-N loss	b	Controlled drainage vs control	+35.20%; -18.90% [a]
Ntot concentration; Ntot loss	b	Controlled drainage vs control	-0.59% ns; -31.80% [a]
Ptot concentration; Ptot loss	b	Controlled drainage vs control	+1.55% ns; -18.79% [a]

[1] (Abdalla, Chivenge, Ciais, & Chaplot, 2016); [2] (Amenumey et al., 2009); [3] (Christianson, Tyndall, & Helmers, 2013); [4] (Skaggs, Youssef, Gilliam, & Evans, 2010); [a] (Z. Wang et al., 2020)

"A meta-analysis indicated that water management options, including single and multiple drainage approaches such as alternative wetting and drying (AWD), significantly reduced CH4 emissions by 35% as a mean effect size (95% confidential interval: 41-29%), as well as the combined effects of CH4+N2O (net GWP) by 29% (36-23%) (Yagi et al., 2019)."

This is very specific for rice cropping systems where during the growing season every now and then the water level is lowered (drained).

5. Tillage

(de Paul Obade & Lal, 2014): non-significant effects for SOC, EC, BD, pH and AWC in Central Ohio, USA; 5 sites with conventional tillage, no-till and natural vegetation land uses.

Table 5. Soil tillage: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest. NT = no-tillage, TT = traditional tillage, CA = conservation agriculture, RT = reduced tillage, MT = minimum tillage.

Parameter	aoi	Management	result
Yield	a	NT vs TT	0 [12, 19, 30, 32]
		NT vs TT	-6% [23]; -5% [24, 27]
		NT vs TT (China)	-2% without, +5% with residues [36]
		NT vs TT (Med.)	7% [13]; ns [31]
		NT vs TT (China)	10% [33]; 3% [35]
Crop yield, weeds in organic farming	a, e	Shallow non-inversion vs TT	-7.6%, +50% [7]
Costs ($ per t C)	d	NT vs TT (North America)	10-400 [20]
GWP* rice	e	NT vs TT (China)	-20% [30]
Yield, CH_4 uptake, N_2O, GHG emissions	a, e	NT vs TT annual wheat and maize.	-3, +23, 0 ns, 0 ns% [34] NE China
CH_4, N_2O	e	NT vs TT without residues	-30%, +82% [37] in rice
CO_2, CH_4, N_2O, GHG	e	NT vs TT	-9% ns, -15%, +10%, 0% [12]
N_2O emission, EF_{ad}**	e	CA vs TT	+18%,+0.40% [21]
CO_2 emissions	e	NT vs TT	-21% [1]
P runoff	e	NT vs TT (dissolved, total, particulate)	+35%, -45%, -55% [8]
Herbicide loss runoff	e	NT vs TT	ns [10]
Pesticide runoff	e	NT vs TT	+55%, +50% [28]
WUE	c	NT vs TT (China)	6% [32]; 10% [33]
AMF colonization	b	Low-intensity tillage vs TT	+27%,
AMF richness			+11% [5]
Bacteria, fauna diversity	b	NT vs TT	+8%, +21% [9]
DOC	b	NT vs TT	Increased [14]
EOC	b	NT vs TT	+17% [15]
NO	e	NT vs TT	-30% [17]
C stock topsoil	b	NT vs TT	0 [18]
Runoff	e	NT vs mouldboard ploughing	-27% [25]
SOC	b	RT and NT vs TT (Med.)	-0,16, +0.85 Mg C ha^{-1} [11] +15%, +11.4% [2]
SOC	b	NT vs TT	0 [26], >0 [1,3,7,31,38]
		CA vs TT	5% [4]
		NT vs TT (China)	3.8-5.1% [29]
SOC, total N, water storage, K avail	b	NT vs TT (China)	10.2%, 9%, 9%, 11% [36]
SOC, beta-gluco, micr. biomass C, dehydrog. activity	b	CA vs TT (Med.)	9%; 18%, 26%,30% [13]
Pot. min. nitrogen	b	CA vs TT	13% [19]
Worms abun, worms mass	b	NT vs TT	137%, 196% [6]
		RT vs TT	50%, 75% [6]
		NT vs TT	90%, 67% [22]
P avail.	b	NT or MT vs TT (Med.)	0 [31]
Total N	b	Idem	0 [31, NT], 9% [13]; >0 [31, MT]
Soil physical parameters	b	NT vs TT	BD 2% [3]; 1-3% [16], AWC 5-10%, Ksat 25%, MWD 52%, PR 37%, WSA 55% [16] ***
C seq.	b	Conservation agriculture vs conventional	+16.3% [a]
Water use	c	Conservation agriculture vs conventional	significant less [a]

Costs and returns	d	Conservation agriculture vs conventional	higher returns and lower costs [a]
CO_2, CH_4	e	Conservation agriculture vs conventional	-4.3%, -25.7% [a]
N_2O, NO_2	e	Conservation agriculture vs conventional	+5.2%, +14.5% [a]
SOC	b	Conservation tillage vs conventional tillage	+5% [b]
SOC	b	No-tillage or reduced tillage tillage vs conventional tillage	+8% [b]
SOC	b	No-till vs mouldboard plough Chisel vs mouldboard plough Perennial vs mouldboard plough	+38% +14% +95% [c]; 0-15 cm depth
MBC, MBN, Resp.	b	No-till vs mouldboard plough Chisel vs mouldboard plough Perennial vs mouldboard plough	+34%, +21%, +49% +34%, +37% (ns), +8% (ns) +131%, +206%, +92% [c]; 0-15 cm depth
Prot, AC, BG	b	No-till vs mouldboard plough Chisel vs mouldboard plough Perennial vs mouldboard plough	+49%, +37%, +55% 3* no data +92%, +225%, +61% [c]; 0-15 cm depth
N-losses[1]	e	Conservation tillage vs traditional tillage	-39.9% [d]
N-losses[1]	e	No-till vs traditional tillage	-63.7% [d]
N-losses[1]	e	Mulch-tillage vs traditional tillage	-25.6% (ns) [d]
SOC	b	No-till vs traditional tillage	+20.9% [e]
pH	b	No-till vs traditional tillage	0% [e]
N total	b	No-till vs traditional tillage	+27.1% [e]
Microbial community	b	No-till vs traditional tillage	+3.0% [e]
Bacterial community	b	No-till vs traditional tillage	+5.5% [e]
Fungal community	b	No-till vs traditional tillage	0% [e]
Microbial biomass	b	Conservation tillage (NT, RT) vs traditional tillage	+37% [f] (ns in sandy soils)
Fungal biomass	b	Conservation tillage (NT, RT) vs traditional tillage	+31% [f] (ns in sandy soils)
Bacterial biomass	b	Conservation tillage (NT, RT) vs traditional tillage	+11% [f] (ns in sandy soils)
SOC	b	Conservation tillage (NT, RT) vs traditional tillage	+22% [f]
N tot	b	Conservation tillage (NT, RT) vs traditional tillage	+22% [f]
Insect and slug pests	b	Reduced tillage vs traditional tillage	ns [g]
Arthropod predators	b	Reduced tillage vs traditional tillage	ns [g]
Runoff	b	Minimum soil disturbance vs conventional tillage (China)	-36.1% [h]
Sediment yield	b	Minimum soil disturbance vs conventional tillage (China)	-51.7% [h]
Bacterial count	b	Reduced tillage vs traditional tillage	0% [i]
Fungal count	b	Reduced tillage vs traditional tillage	+16% (ns) [i]
Bacterial count	b	No-till vs traditional tillage	+14% [i]
Fungal count	b	No-till vs traditional tillage	+58% (ns) [i]
MWD (0-5 cm)	b	No-till vs traditional tillage	+57.9% [j]
Field capacity (0-5 cm)	b	No-till vs traditional tillage	+15.5% [j]
Dry bulk density (5-10 cm)	b	No-till vs traditional tillage	+4.7 (ns) [j]
Infiltration rate	b	No-till vs traditional tillage	+66% [j]
SOC - total	b	No-till vs traditional tillage	+1.1% (ns) [j]
SOC (0-5 cm)	b	No-till vs traditional tillage	+37.9% [j]
Lrv (0-5 cm)	b	No-till vs traditional tillage	+34.7% [j]
Lrv (other depths)	b	No-till vs traditional tillage	ns [j]
Yield	a	Occasional tillage vs no-till	ns [k]

Yield	a	Occasional subsoiler tillage vs no-till	+36% [k]
Dry bulk density	b	Occasional tillage vs no-till	-6.9% [k]
Penetration resistance	b	Occasional tillage vs no-till	-54.8% [k]
Macroporosity	b	Occasional tillage vs no-till	+45.4% [k]
Total porosity	b	Occasional tillage vs no-till	+10.6% [k]
SOC	b	Occasional tillage vs no-till	-4.7% [k]
Aggregate size (> 2 mm)	b	Occasional tillage vs no-till	-12.5% [k]
MWD	b	Occasional tillage vs no-till	-10.7% [k]
pH	b	Occasional tillage vs no-till	ns [k]
P avail.	b	Occasional tillage vs no-till	ns [k]
MBC	b	Occasional tillage vs no-till	+21.2% [k]
Total microbial activity (TMA)	b	Occasional tillage vs no-till	ns [k]
Infiltration	b	Occasional tillage vs no-till	+120% [k]
Mulch cover	b	Occasional tillage vs no-till	-40.4% [k]
Runoff	b	Occasional tillage vs no-till	-26.1% [k]
Weeds	a	Occasional tillage vs no-till	-70% [k]
Runoff	b	Contour tillage vs traditional tillage (China)	-35.86% [l]
Sediment transport	b	Contour tillage vs traditional tillage (China)	-49.02% [l]
SOC	b	No-till vs traditional tillage	Decreasing from ~10-15% to 0% with increasing humidity index (HI = mean annual precipitation divided by mean annual temperature) [m]
Yield	a	No-till vs traditional tillage	Decreasing from 0% with increasing humidity index (HI = mean annual precipitation divided by mean annual temperature), strongly linearly related with SOC [m]
Yield	a	Minimum tillage vs traditional tillage (fruit, Med.)	-8.3% ns [n]
Yield	a	No-till vs traditional tillage (fruit, Med.)	+1.7% ns [n]
SOC	b	Minimum tillage vs traditional tillage (fruit, Med.)	+44.5% [n]
SOC	b	No-till vs traditional tillage (fruit, Med.)	+38.3% [n]
C seq.	b	Minimum tillage vs traditional tillage (fruit, Med.)	1.51 Mg C ha^{-1} $year^{-1}$, ns [n]
C seq.	b	No-till vs traditional tillage (fruit, Med.)	1.39 Mg C ha^{-1} $year^{-1}$, ns [n]
N tot.	b	Minimum tillage vs traditional tillage (fruit, Med.)	+34.4% [n]
N tot.	b	No-till vs traditional tillage (fruit, Med.)	+26.4% ns [n]
P avail.	b	Minimum tillage vs traditional tillage (fruit, Med.)	+5.0% ns [n]
P avail.	b	No-till vs traditional tillage (fruit, Med.)	+1.6% ns [n]
Yield (wheat)	a	Subsoiling vs traditional tillage (N. China)	+16.3% [o]
Yield (maize)	a	Subsoiling vs traditional tillage (N. China)	+9.2% [o]
Water consumption (wheat)	c	Subsoiling vs traditional tillage (N. China)	+8.4% [o]
Water consumption (maize)	c	Subsoiling vs traditional tillage (N. China)	+1.8% [o]
Bulk density	b	No-till vs traditional tillage	+2.3% [p]
Penetration resistance	b	No-till vs traditional tillage	+27.8% [p]
pH	b	No-till vs traditional tillage	-1.8% [p]
MWD	b	No-till vs traditional tillage	+50% [p]
WSA	b	No-till vs traditional tillage	+36% [p]
Ksat	b	No-till vs traditional tillage	0% [p]
AWC	b	No-till vs traditional tillage	+8.7% [p]

Yield (maize)	a	Ridge-furrow cultivation vs control	47% [q]
WUE, ET	c	Ridge-furrow cultivation vs control	39%, 0 [q]

[1] (Abdalla et al., 2016); [2] (Aguilera, Lassaletta, Gattinger, & Gimeno, 2013); [3] (Angers & Eriksen-Hamel, 2008); [4] (Bai et al., 2019b); [5] (T. M. Bowles, L. E. Jackson, M. Loeher, & T. R. Cavagnaro, 2016); [6] (Briones & Schmidt, 2017); [7] (Cooper et al., 2014); [8] (Daryanto et al., 2017); [9] (de Graaff, Hornslein, Throop, Kardol, & van Diepen, 2019); [10] (Elias, Wang, & Jacinthe, 2018); [11] (González-Sánchez, Ordóñez-Fernández, Carbonell-Bojollo, Veroz-González, & Gil-Ribes, 2012); [12] (Huang et al., 2018); [13] (Lee et al., 2019); [14] (M. Li, Wang, Guo, Yang, & Fu, 2019); [15] (S. Li et al., 2018); [16] (Y. Li, Li, Cui, Jagadamma, & Zhang, 2019); [17] *not used*; [18] (Z. Luo, Wang, & Sun, 2010); [19] (Mahal, Castellano, & Miguez, 2018); [20] (Manley, Van Kooten, Moeltner, & Johnson, 2005); [21] (Mei et al., 2018); [22] (Moos, Schrader, & Paulsen, 2017); [23] (C. M. Pittelkow et al., 2015); [24] (Cameron M. Pittelkow et al., 2015); [25] (Y. Sun, Zeng, Shi, Pan, & Huang, 2015); [26] (Ugarte, Kwon, Andrews, & Wander, 2014); [27] (Van den Putte et al., 2010); [28] (Velthof); [29] (Z. Du, Angers, Ren, Zhang, & Li, 2017); [30] (Feng et al., 2013); [31] (Morugán-Coronado et al., 2020); [32] (Wang, Zhang, Zhou, & Wang, 2018); [33] (Wei et al., 2017); [34](C. Xu et al., 2017); [35] (Yin et al., 2018); [36] (Zhao et al., 2017); [37] (Zhao et al., 2016); [38] (Zhao et al., 2015); [a] (Kiran Kumara, Kandpal, & Pal, 2020); [b] (Bai et al., 2019a); [c] (Nunes, Karlen, Veum, Moorman, & Cambardella, 2020) their Table 2; [d] (Y. Zhang, Xie, Ni, & Zeng, 2020); [e] (Yüze Li et al., 2020); [f] (H. Chen et al., 2020); [g] (Rowen, Regan, Barbercheck, & Tooker, 2020); [h] (Jia et al., 2019); [i] (Y. Li, Zhang, Cai, Yang, & Chang, 2020); [j] (Mondal, Chakraborty, Bandyopadhyay, Aggarwal, & Rana, 2020); [k] (Peixoto et al., 2020); [l] (Jia, Zhao, Zhai, An, & Pereira, 2020); [m] (W. Sun et al., 2020); [n] (Morugán-Coronado et al., 2020); [o] (J. Wang et al., 2020); [p] (Y. Li, Li, Cui, & Zhang, 2020); [q] (Y. Wang et al., 2020)

[1]: N-losses: gaseous emission and leaching; * GWP: yield-scaled global warming potential (CH_4 and N_2O emissions per unit rice yield), ** EF_{ad}: additional N_2O emission factor, which is the conservation tillage-induced change in N2O emission compared to conventional tillage when N fertilizer is applied.*** BD: bul density, AWC: available water content, Ksat: saturated hydraulic conductivity, MWD: mean weight diameter, PR: penetration resistance of soil, WSA: water stable aggregates. MBC = microbial biomass c; MBN = microbial biomass N; Resp = soil respiration; Prot = soil protein; AC = active carbon; BG = beta-glucosidase, WSA = water stable aggregates, AWC = available water content, MWD = mean weight diameter

6. Pest management

Table 6. Pest management: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aoi	Management	Result
Yield	a	Effect of biofumigation	Abs. diff.: 29% [a]
Yield	a	Anaerobic soil disinfestation	Abs. diff.: 30% [b]
Suppression of pathogens	a	Anaerobic soil disinfestation	Abs. diff.: 70% [b]
Yield	a	Organic / conventional	Ratio: 0.83 [c]
Disease severity response by fungal plant pathogens	b	Fertilized vs unfertilized	increase 0.3±0.1 [d]
Nr studies with insect population	b	Fertilisation	Increase/decrease 175/78 [e]
Nr studies with pest population	b	Organic /non-organic	Increase/decrease 42/26e[f]
Pest infestation; weed	e	Organic vs conventional	- hedge's d=1.02± 0.22 [g]
Pest infestation; Animal pest			ns [g]
Pest infestation; pathogen			- hedge's d=0.38± 0.23 [g]

[a] (Morris, Fletcher, & Veresoglou, 2019); [b] (Shrestha, Augé, & Butler, 2016) [c] (Lesur-Dumoulin, Malézieux, Ben-Ari, Langlais, & Makowski, 2017); [d] (Veresoglou, Barto, Menexes, & Rillig, 2013) [e] (Butler, Garratt, & Leather, 2012); [f] (Garratt, Wright, & Leather, 2011); [g] (Muneret et al., 2018).

7. Weed management

Table 7. Weed management: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aoi	Management	Result
weed biomass	a	Legume intercropping vs conventional, both non-weeded and weeded	-56%, -42% [a]
Weed density, biomass parasitic nematodes	a	Cover crops vs TT	-10%, -5%, +29% [b]
Number of studies with increase soil organic matter	b	Reduced tillage/Tillage	+40 and -7 out of 78 studies [c]
Soil microbial respiration	b	Glyphosate vs no use, <10 mg kg	Log RR: 0.064±0.126 [d]
Soil microbial biomass		Glyphosate vs no use, >10 mg kg	Log RR: 0.04±0.09 [d]

[a] (Verret et al., 2017); [b] (Daryanto et al., 2017); [c] (Govaerts et al., 2009); [d], (Nguyen, Rose, Rose, Morris, & Van Zwieten, 2016).

*OA: organic agriculture

8. Crop residue management & mulching

Table 8. Crop residue management & mulching: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aoi	Management	Result
Yield, rotation Yield, no rotation	a a	Residue vs control, overall Residue vs control, overall, maize	+1% ns, +2% ns, 20% [f]
C microbial biomass	b	Amendment vs control	+36% [a]
N_2O emission factor	e	Amendment vs control	0.5±0.3% [b]
N_2O release	e	Residue vs control (both include mineral fertilizer) Residue vs control (both without mineral fertilizer) Residue vs control (both upland soil)	-11.7% [c] 41.1% [c] 23.5% [c]
N_2O release	e	Residue vs control	sign. [d]
N_2O release	e e	Residue vs control Residue with C/N<25 vs control	+11% [e] +76% [e]
yield yield NUE* NUE* WUE** WUE **	a a c c c c	Mulching plastic or straw in wheat vs conv Mulching plastic or straw in potato vs conv Mulching plastic or straw in wheat vs conv Mulching plastic or straw in maize vs conv Mulching plastic or straw in maize vs conv Mulching plastic or straw in potato vs conv	20%; 20% [g] 61%; 20% [g] 20%; 20% [g] 60%; 21% [g] 20%; 20% [g] 59%; 21% [g]
Yield WUE	a c	Mulching plastic or straw in maize vs conv	29.4%; 12.02% [s] 29.45%; 11.43% [s]
Yield, WUE	a,c	Degradable film mulching vs none	+17%,+21%[h]
Yield, WUE	a,c	Crop residue vs none	+5%, + 14.8 [l]
Yield soil temperature	a,b	Degradable vs polyethylene mulching	ns [p] -4.5% [p]
Yield, WUE	a,c	Degradable vs polyethylene mulching	-3%, -3% [h]
yield	a	degradable vs polyethylene mulch	Ns. [q]
Yield wheat, maize	a	Mulching in NE China	+14.9 ± 2.9%, +17.7 ± 6.2% [k]
Yield, water use, WP	a, c	Plastic film mulching in NE China vs none Straw re-incorporation vs none	+14, -2.8, +17.4% [m] +8.5, -4.1, +12.6%[m]
Yield Economic return N footprint*	a d e	Plastic mulching in potato, maize, wheat in China	25, 27, 20%[j] 19, 29, 22% [j] 19, 37, 19% [j]
Grain yield maize	a	Plastic film mulching in loess plateau China	+56.1% [k]
Yield potato WUE	a, c	Mulching plastic or straw in China vs conv	24.3%, 16% [r] 287%, 5.6% [r]
SOC storage CH4 emission	b,e	Plastic mulching	+ 0.0102 Mg C $ha^{-1}y^{-1}$ [i] - 0.25 kg C ha^{-1} y^{-1} [i]
Yield SOC, CO_2, CH_4, N_2O	a b e	Crop residue retention vs none	+7.8%[n] 12-36.8% [n] +31.7, +130.9, +12.2% [n]
Soil C:N, Soil C:P soil N:P	b	Living mulch in tree orchards in China	n.s. [o] 12% [o] 10% [o]
Yield CO_2 emissions	a,e	Optimal mulching & conservation (clean) vs conventional for whole China	+6.89% [q] -75% [q]

[a] (Kallenbach & Grandy, 2011); [b] (Charles et al., 2017); [c] (Shan & Yan, 2013); [d] (Chen, Li, Hu, & Shi, 2013); [e] (Essich, Nkebiwe, Schneider, & Ruser, 2020); [f] (Cameron M. Pittelkow et al., 2015); [g] (Qin, Hu, & Oenema, 2015); [h] (Gu et al., 2020); [i] (Mo et al., 2020); [j] (L. Wang et al., 2020); [k] (N. Wang et al., 2020); [l] (X. Lu, 2020); [m] (H. Zheng et al., 2020); [n] (X. Zhao et al., 2020); [o] (G. Chen et al., 2020); [p] (Tofanelli & Wortman, 2020); [q] (Xiao, Zhao, & Zhang, 2020); [r] (Q. Li, Li, Zhang, Zhang, & Chen, 2018); [s] (Gao et al., 2019).

*NUE: yield per unit of N **WUE: yield per unit of water

9. Mechanization & technology

No meta-analysis studies/reviews found: no data (no table; no figure).

Parameter	aoi	Management	Result
Dry bulk density	b	After trafficking versus before trafficking (forest soils)	0-10 cm: for 98 studies; 76 showed increase, 22 showed decrease; 26 showed increase > 15% [a] 10-20 cm: for 102 studies; 76 showed increase, 26 showed decrease; 13 showed increase > 15% [a] 20-30 cm: for 88 studies; 57 showed increase, 31 showed decrease; 3 showed increase > 15% [a]
Labour input: preparation, weeding, total	d	Planting basins vs conventional tillage	+702%, +35%, +81 [b]
Labour input: preparation, weeding, total	d	Ridged systems vs conventional tillage	+19%, -44%, +9% [b]
Labour input: preparation, weeding, total	d	No-till vs conventional tillage	-83%, -90%, -25% [b]
Change in yield relative to change in labour	a/d	Planting basins vs conventional tillage	0.16 (preparation), 0.66 (weeding) no data (total) [b]
Change in yield relative to change in labour	a/d	Ridged systems vs conventional tillage	2.0 (preparation), 3.4 (weeding), 2.2 (total) [b]
Change in yield relative to change in labour	a/d	No-till vs conventional tillage	With herbicides: 1.7 (preparation), 2.6 (weeding), 1.8 (total) [b] Manual weeding only: 3.3 (preparation), 0.6 (weeding), 0.9 (total) [b]

[a] (Ampoorter, de Schrijver, van Nevel, Hermy, & Verheyen, 2012); [b] (Dahlin & Rusinamhodzi, 2019)

10. Landscape management

Table 9. Landscape management: effects on (a) crop yield and quality, (b) soil quality, (c) economic effects, (d) resource use efficiency, (e) environmental effects, and (f) human health impacts as reported in meta-analysis studies; aoi = area of interest.

Parameter	aoi	Management	Result
Crop yield increase	a	Wind breaks	Spring wheat +8%, winter wheat +23%, barley +25%, oats +6%, rye +19%, millet +44%, corn +12%, alfalfa +99%, hay +20% [a]
Crop yield	a	Hedgerows vs control; next to hedge until twice the height; beyond twice the height until 20 times the height	-29%, +6% [b]
Soil organic matter in crop field	b	Hedgerows vs control	6% [b]
Interception of N, P, suspended solids from soil surface flow	e	Hedgerows Grass strips	69%,67%, 91%[b] 67%, 73%, 90% [b]
Crop yield	a	Hedge rows, Flower strips vs none	Ns [c]
Pest control	e	Hedge rows, Flower strips vs none	ns, -16% [c]
Pollination	e	Hedge rows, Flower strips vs none	ns [c]
Abundance, richness of pollinators in crop	e	Flower strips vs none	ns, ns [d]
Pollinator species richness	e	effect of Agri-environment management in intensive land use, landscape: Small, simple Small, complex Large, simple Large, complex	Hedge's d: sign. [f] ns [f] sign. [f] Sign. [f]
Soil SOM, total N, total P, alkali N, available P, readily available K, total K	b	hedge rows vs none	Hedge's d sign. [c] Hedge's d ns [c]

[a] (Kort, 1988); [b] (Van Vooren et al., 2017); [c] (Albrecht et al., 2020); [d] (Zamorano, Bartomeus, Grez, & Garibaldi, 2020); [e] (Y. Zheng, Wang, Qin, & Wang, 2020); [f] (Marja et al., 2019).

Brief description Excel file

While collecting the data, additional meta-information was summarized in an Excel table, which is available as a separate document (LINK). In that table additional information can be found of non-meta-analysis studies as well. The meta-information that was collected (as far as provided by the original studies) is given in Table 10.

Table 10. Explanation of the main columns in the accompanying Excel-sheet.

Column header	Explanation
SICS impact on	Impact on either a) Agronomic effects, b) Soil quality & soil health, c) Resource use efficiency, d) Economic aspects, or e) Environmental impacts.
Reference	Reference.
Country	Indication whether the data refer to a global analysis or more specifically to a smaller region or country.
Type of study	Meta-analysis, review, review (single study), single study.
Short description	Brief description of the contents of the study.
Parameter	Name of variable for which the effect size is provided.
Crop	Name of crop studied (if provided).
Soil	Soil type (not always available).
Year(s)	Years from which data were collected.
Depth	Soil depth to which variable refers to (if provided).
Control_description	Description of control treatment.
Treatment_description	Description of the treatment under investigation.
Unit	Unit of the variable.
Control_data	Quantity of the variable for the control treatment.
Treatment_data	Quantity of the variable for the treatment under investigation.
Absolute difference	Treatment_data - Control_data
Factor	Treatment_data / Control_data
Relative change	Treatment_data / Control_data - 1
L	LN(Treatment_data / Control_data)
Significant according to authors	Indication if authors provided information on significance of their findings.

In some cases only the final relative effect size (Factor, Relative change or L) was provided. In other cases only the absolute values for control and treatment were given, from which we calculated the relative effect size information. In rare cases only the absolute difference (without reference) was given, so that no relative effect size could be computed. For a few studies this Excel sheet contains, besides the reported main effects, also effects split in sub-effects; for example, effects split for arid versus humid regions, effects split for different soil types, or effects split for different crops. It goes beyond the scope of our study to provide all full details of the underlying meta-analysis studies.

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