SINGLE-IMPACT FICHE
INTERCROPPING

IMPACT: PLANT NUTRIENT UPTAKE

Data extracted in May 2021

Note to the reader: This fiche summarises the impact of intercropping on PLANT NUTRIENT UPTAKE (namely nutrients use efficiency). It is based on 5 peer-reviewed synthesis research papers[1], each of them including from 17 to 132 individual studies.

1. WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT:
  Intercropping of multiple crop species (i.e., crop mixture cropping), as compared to monoculture, resulted in an overall positive effect on nutrient (both nitrogen and phosphorous) use efficiency (i.e., increase in nutrient use efficiency). From a total of 6 results, 5 were positive and one showed no-effect (see **Table 1**).

  Among the 5 reviewed synthesis papers, 4 include data collected in Europe (see **Table 2**).

Table 1. Summary of effects. The numbers between parenthesis indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section.

		All studies				Only studies including EU			
Impact	**Intervention**	**Positive**	**Negative**	**No effect**	**Uncertain**	**Positive**	**Negative**	**No effect**	**Uncertain**
Increase Nutrient use efficiency	Crop mixture	5 (5)	0	1 (1)	0	4 (4)	0	0	0

QUALITY OF THE SYNTHESIS PAPERS: *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in in the methodology section of this WIKI.*

2. IMPACTS

The main characteristics and results of the synthesis papers are summarized in **Table 2**. Summaries of the meta-analyses provide fuller information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices.

Table 2. Main characteristics of the synthesis papers reporting impacts of intercropping on plant nutrient uptake.

[1] Research synthesis papers include a formal meta-analysis or systematic reviews with some quantitative results. Details can be found in the methodology section of the WIKI.

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Li, CJ; Hoffland, E; Kuyper, TW; Yu, Y; Zhang, CC; Li, HG; Zhang, FS; van der Werf, W 2020	Multiple crops	Global	132	Crop mixture cropping	Monoculture	Nitrogen fertilizer equivalent ratio (NFER) and phosphorus fertilizer equivalent ratio (PFER)	Intercropping saves nitrogen and phosphorus fertilizer compared with sole crop, offering opportunities for the sustainable intensification of both high- and low-input agriculture.	69%
Tang, XY; Zhang, CC; Yu, Y; Shen, JB; van der Werf, W; Zhang, FS 2021	Cereals and legumes	Global	17	Crop mixture cropping	Monoculture	Phosphorus use efficiency (Land equivalent ratio for P uptake, LERP; Net effect for P uptake, NEP)	Cereal/legume intercropping can increase the uptake of P and hence has the potential to increase P fertilizer use efficiency in agriculture.	75%
Rodriguez, C; Carlsson, G; Englund, JE; Flohr, A; Pelzer, E; Jeuffroy, MH; Makowski, D; Jensen, ES 2020	Cereals and legumes	Global	29	Crop mixture cropping	Monoculture	Dinitrogen (N_2) fixation and Soil-derived N acquisition	The meta-analysis confirms and highlights that intercropping consistently stimulates complementary N use between legumes and cereals by increasing N_2 fixation by grain legumes and increasing soil N acquisition in cereals. Cropping systems diversification via intercropping can be used for simultaneous production of both cereals and grain legumes, while increasing the use of N-sources and reducing external inputs of N fertilizers, thereby enhancing the sustainability of agriculture.	88%
Xu, Z; Li, CJ; Zhang, CC; Yu, Y; van der Werf, W; Zhang, FS 2020	Maize and soybean	Global	100	Crop mixture cropping	Monoculture	Nitrogen fertilizer equivalent ratio (FNER)	Exploiting species complementarities by intercropping maize and soybean enables major increases in land productivity with less fertilizer N use.	94%
Thapa, R; Poffenbarger, H; Tully, KL; Ackroyd, VJ; Kramer, M; Mirsky, SB 2018	Cover crops: hairy vetch (Vicia villosa Roth)–cereal rye (Secale cereale L.)	United States	21	Crop mixture cropping	Monoculture	Nitrogen content in the aboveground biomass of cover crops[2]	Overall, the study suggests that legume–grass mixtures, in this case hairy vetch–cereal rye, have the potential to maximize cover crop nitrogen content, better synchronizing nitrogen release with nitrogen demand of the succeeding cash crop, than either monoculture species, accumulating as much nitrogen as	75%

[2] Authors consider Plant N content in cover crops as an indicator of nutrient use efficiency:
"Aboveground biomass and N content are proxies that indicate the potential value of cover crop monocultures or mixtures in terms of agroecosystem services provisioned. Cover crop biomass is positively correlated with weed suppression and retention of N against leaching loss in some regions. Cover crop N content is a key predictor of N supply to the subsequent crop, particularly in combination with cover crop C/N ratio. (…) Based on our findings, hairy vetch–cereal rye mixtures are recommended over monocultures when the goal is to maximize both cover crop biomass and N content, and better synchronize N release with N demand of the succeeding cash crop."

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
							pure hairy vetch.	

3. KNOWLEDGE GAPS

Li et al., 2020	Further research is needed to assess the environmental benefits of the high-input intercropping strategy compared with sole crops or reduced-input intercrops.
Xu et al., 2020	Further research is needed to identify optimal combinations of planting configuration, sowing dates and fertilizer to achieve high yields and high N use efficiency in intercropping, and exploit biological N fixation without driving the system to very resource poor low yielding conditions.
Thapa et al., 2018	Future studies evaluating cover crop mixtures over monocultures should consider the multiple factors that influence mixtures productivity, including soil N availability and precipitation during cover crop growth period. Future studies should also prioritize research on belowground biomass and N accumulation with cover crop mixtures relative to monocultures.