FARMING PRACTICE INTERCROPPING

IMPACT: CROP YIELD

Reference 9

Ashworth, AJ; Toler, HD; Allen, FL; Auge, RM 2018 Global meta-analysis reveals agro-grassland productivity varies based on species diversity over time PloS One 13, e0200274. 10.1371/journal.pone.0200274

Background and objective

Ecological research suggests increased diversity may improve ecosystem services, as well as yield stability; however, such theories are sometimes disproven by agronomic research, particularly at higher diversity levels. Authors tested: if biological N2 fixation (BNF) supplies adequate nitrogen (N) for plant growth relative to synthetic fertilizers; how crop physiological traits affect legume-grass symbiosis; and, how cultural practices affect BNF over a range of soils and climates overtime (in polycultures versus sole grasslands).

Search strategy and selection criteria

On 11 November 2015 authors conducted a two-tiered search on the Web of Science Core Collection, CAB International, MEDLINE, Biological Abstracts, FSTA (Food Science and Technology Abstracts) and Zoological Record databases, using the ISI Web of Science search tool. A search of these records using selected terms (i.e., legume intercrop, grass, mixture, forage, agriculture, AND yield), resulted in a total of 791 unique publications. inclusion criteria: means for both intercrop and inter-crop treatments were not presented; sole grass (control) yields were not reported; article was a duplicate; article did not contain primary data (no review or book); articles were not obtainable using interlibrary loan services, were refereed articles, or were conference proceedings, research reports, and bulletins.

Data and analysis

Authors calculated the natural logarithm of the response ratio. A random-effects model was used. Summary effect (mean ES across studies) were estimated using Comprehensive Meta-Analysis (CMA) software (Version 3, Biostat, Englewood, NJ, USA; 2014). Individual studies within the meta-analyses were weighted using non-parametric variance.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
48	Agro-grasslands	Intercropping	Monoculture	Metric: Total aboveground production (net primary productivity); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	81.25

Results

- Globally, net primary productivity (NPP; total aboveground production response of grass and legume in higher diversity treatments) increased 44% via legume associations relative to sole grass controls (including both with and without N fertilizer).
- Leguminous intercrops increased grass tissue-N by 32% (P<0.0001; CI: 0.14±0.40).
- Fodder digestibility was not affected (P>0.05) by intercropping.

Factors influencing effect sizes

- Fertiliser application : More diverse plant communities, when compared to their sole grass counterparts, yielded 66% more total biomass when receiving no N-fertilizer. However, symbiotic effects were less pronounced when sole grass received 8±100 kg N ha-1, resulting in a 32% increase. Effects from intercropping continued to decrease with increased sole grass fertilization comparisons (101±200 and 201±500 kg N ha-1), resulting in 14 and 8% NPP increases, respectively (not significant).
- Crop type : Grasses with C_3 photosynthesis, when grown in polycultures with legumes, resulted in a 57% increase from grasslands with grasses alone, whereas C_4 grasses resulted in only a 31% increase (LnR = 0.27). Effect of intercropping varied with grass genera: e.g. the summary effect was 2.9 and 2.3 x the magnitude of the control group for Bouteloua and Sorghastrum and only 0.98 for Schedonorus (192, 129, and -2% change,respectively). C_4 grass polycultures had 48% greater CP when grown in mixtures compared to monocultures, whereas diverse C_3 grass mixtures only increased CP by 21%.
- Crop/cultivar combinations : Warm-season legumes had reduced efficacy in mixtures (27% increase) compared to cool-season legume species. Polyculture yield response for perennial legumes was 50% greater than controls (all sole grass stands with and without fertilizer), followed by a 28% increase for biennial legumes, and a 0% increase for annual legumes. Including only one legume resulted in the highest (P<0.05) percent increase in NPP (52%), whereas two legumes in a mixture resulted in only 6% increases. Warm-season legume polycultures also had higher CP compared to their cool-season counterparts (52 vs. 23%). Annual legume intercrops only increased CP 10% compared to a 38 and 35% for biennial and perennial species, respectively.
- Climate : Effects were greatest (114% change) in Mediterranean climates followed by oceanic (84%), and tropical savanna (65%) environments; conversely, semiarid and subarctic systems had lowest changes (5 and 0% change, respectively).
- Soil texture : A 122% NPP increase was observed in silt clay soils compared to 14% for silt loam soils. Soils with higher cation exchange capacity (i.e., silty clay, clay loam), compared to more drought prone textural classes (i.e., loamy sand and sandy loam) resulted in higher CP.

Conclusion

Legume intercropping may be one component of the management portfolio that reduces greenhouse gas emissions and chemical inputs, while maintaining NPP and fodder quality to the largest agricultural land base: agro-grasslands.