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Yield Gap Analysis Extended to Marketable Grain Reveals the Profitability of Organic Lentil-Spring Wheat Intercrops

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Abstract:

Introduction: Lentil (*Lens culinaris* Med.) is a popular legume that has many advantages for nutrition and –as other legumes– for agriculture, such as reduced need for synthetic fertilizers and improved N availability for the following crop. Yet, lentil has been overlooked by farmers in Europe mainly because of its low and unstable yields, notably due to frequent lodging, bruchid beetles damages and weed competition.

Intercropping is the simultaneous growth of two or more species in the same field for a significant period. Like other legume-cereal intercrops that have been shown to increase total yield and gross margin, lentil-wheat intercrops may be a way to increase lentil production by reducing pests and weeds damages.

The issues of lodging and bruchid damage in lentil were analysed by adapting the "yield gap" concept which identifies and quantifies "limiting" and "reducing" factors of a crop. Here, we addressed three questions: do lentil-spring wheat intercrops have i) higher total grain yield?, ii) higher mechanical harvest efficiency?, and iii) higher profitability than sole cropped lentil?

Material and methods: A two-year field experiment was carried out in SW France in 2015 and 2016 under organic farming rules. Four lentil and two spring wheat cultivars were grown as sole crops and bispecific intercrops grown in partial additive design (100%L:17%W). The "yield gap" concept was adapted to estimate all grain losses by adding losses during mechanical harvest and losses due to insufficient quality.

Results: Mean total intercrop grain yield before mechanical harvest was higher than mean sole crop yield (1.91±0.47 vs. 1.57±0.29 t ha^{-1}, respectively), with a lower mean yield of lentil in intercrop than in sole crop (1.06±0.28 vs. 1.61±0.54 t ha^{-1}, respectively). This led to a lower mean gross margin of intercrops than lentil sole cropped (1797±469 vs. 2396±706 € ha^{-1}, respectively) based on actual yield before mechanical harvest.

The percentage of bruchid-damaged grain did not differ significantly between intercrop and sole crop lentil (ca. 41%). However, lentil lodging was much lower in intercrop than in sole crop (15% vs. 40%, respectively), which increased lentil harvest efficiency (75% vs. 50%, respectively). This led to a similar mechanically harvested yield of lentil in intercrop and sole crop (0.80 t ha^{-1}).

Consequently, mean marketable gross margin of intercrops was higher than that of sole cropped lentil and wheat (974±376 vs. 713±348 and 304±26 € ha^{-1}, respectively) due to the addition of marketable wheat yield, and far higher than the margin of sole cropped wheat.

Conclusion: We thus demonstrated the profitability of organic lentil-spring wheat intercrops, mainly due to greater mechanical harvest efficiency, despite the additional costs of grain sorting and cleaning after harvest. This demonstrates the relevance of extending the yield gap concept to include all grain losses for assessing profitability of intercrops.

Keywords: Lodging, bruchid, harvest efficiency, gross margin

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