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Chapter 1:4

Intercropped barley for brewing and distilling

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Introduction

Of the Scottish arable area (547,500 hectares (ha) in 2015), 56 % was sown with barley, of which 83 % (256,000 ha) was spring barley (Scottish Government, 2016a). From this area, around 1.9 million tonnes (mt) of barley is harvested and the yield from spring barley varieties for malting to serve brewing and distilling industries account for 35% of production, the remainder being routed to animal feed markets (Scottish Government, 2016a). The alcohol industry is very important economically generating over £996 million in duty (Scottish Government, 2016b). The whisky industry alone, when considering both direct and induced effects, contributes £4.7 billion to the economy (SWA, 2017).

To support the necessary yields of this important crop an average of around 110 kg/ha of inorganic nitrogen fertiliser (usually as ammonium nitrate, AN) is applied (DEFRA, 2016) with an associated carbon footprint, expressed as carbon dioxide equivalents (CO2e), of 3.06 kg/kg AN (Fertilizers Europe, 2014). The nitrogen requirement could be provided by legume-supported intercropping (Brooker, Bennett, Cong, Daniell, George, Hallett, Hawes, Iannetta, Jones, Karley, Li, McKenzie, Pakeman, Paterson, Schöb, Shen, Squire, Watson, Zhang, Zhang, Zhang and White, 2015; Iannetta, Young, Bachinger, Bergkvist, Lopez-Bellido, Doltra, Monti, Pappa, Reckling, Topp, Walker, Rees, Watson, James, Squire and Begg, 2016): that is, two crops species are sown in the same field at the same time, and the nitrogen requirement of the cereal is facilitated by biological fixed nitrogen delivered from the legume companion. If achievable, for the spring barley area of Scotland, the financial and CO2e savings would be around £6.8 million (for 256k ha of spring barley using 110 kg/hectare of fertiliser costing £241.5/tonne, as per the average January 2017 34.5 % Ammonium Nitrate price; ADHB, 2017) and 86 kt CO2e, respectively (at 3.06 kg CO2e/kg AN, Fertilizers Europe, 2014). The potential of an alternative legume supported cropping system assessed the yield and yield qualities of barley from a 50:50 pea-supported intercrop to serve the brewing and distilling industries.

Materials and methods

Field experiments were conducted at the James Hutton Institute, Invergowrie in 2015. Each treatment was replicated 6 times in a randomised split block design. Individual plots were 1.25 m × 4.5 m. Five barley and five pea cultivars were grown as monocrops (full, 100 % of recommended seeding rate) and in combinations (50:50 seeding rate). A sixth barley treatment was formed using all five cultivars at a 10 % seeding rate per cultivar. The same was done for the pea cultivars and they were sown, combined, as an intercrop. All plots received pre-emergence weed control but no fertiliser, pesticide or later weed control. Desiccant was applied at maturity of the barley (glyphosate). During growth, data was collected on pea establishment rate and number of barley tillers and statistical analysis employed ANOVA to test for statistical differences (at $P \leq 0.05$). The Land Equivalent Ratio (LER), defined as the area needed under sole cropping to produce the same amount as 1 ha of intercropping, can be calculated usingthe equation: [Intercrop 1 / Monocrop 1] + [Intercrop 2 / Monocrop 2]).

Results and discussion

Average tiller production, the number of barley stems produced per seed sown, was significantly higher in intercrops compared to monocrops (Figure

1) with 1.9 and 1.1 tillers per seed sown, respectively. More tillers lead to more grain heads and higher yields - probably a consequence of a greater volume of space available from reduced sowing density, and other facilitive processes associated with intercropping. Intercropped barley yields (Figure 2) were not significantly different to that of the monocrop (without fertiliser yields) at around 4.5 t/ha, depending on cultivar. This is only ca. 20% lower than the 10-year barley yield average (to 2016), for Scotland at 5.7 t/ha (Scottish Government, 2016c).

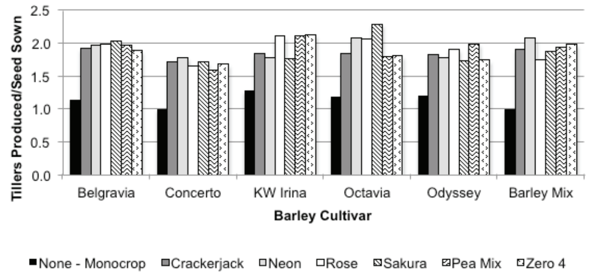

Figure 1. Quantity of barley tillers for monocrops (avg. 1.1 tillers/seed) and intercrops (avg. 1.9 tillers/seed), the latter defined relative to pea cultivar and cultivar combination (Pea Mix).

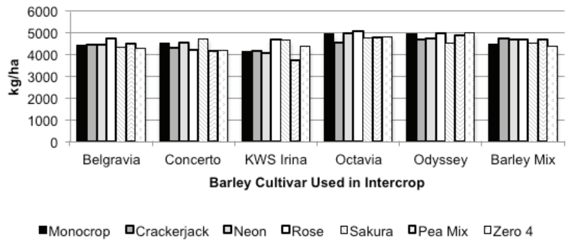

Figure 2. Barley yield (kg/ha) for monocrops and intercrops, the latter defined relative to pea cultivar and cultivar combination (Pea Mix).

This was achieved despite the 50 % seeding rate, and highlighting the potential compensation effect of extra-tiller capacity to maintain yields. Compared to the mono-cropped control, no obvious cultivar effect upon yield was found, for pea or barley. Intercropped pea yield was reduced x6.4 compared to the monocrop, and this may have been due to pigeon damage at the seeding stage. Future trials will be protected by nets during early crop development. The LER value (Table 1) for the combined barley-pea intercrop was slightly greater than 1 indicating an increase in absolute grain yields for the area cultivated of 15 %, and indicative of a potential decrease in land requirements of 15 %. The increased LER can compensate for the reduced yields compared to with-fertiliser treatment yields. Malting studies of the intercropped barley remain to be carried out, though initial grain %N analysis from this harvest shows an average of 1.3, 0.1 of a % above the mono-cropped control.

Treatment (seeding rate % of conventional)	Yield (kg/ha) Barley	Pea	Total	LER
Barley, monocrop (100 %)	4595		4595	
Pea, monocrop (100 %)		1917	1917	
Barley-Pea Intercrop (50 %)	4590	299	4890	1.15

Table 1: Grain yield of barley and pea and Land Equivalency Ratio (LER) for barley and pea grown as monocrops and as an intercrop with no fertiliser or post emergence weed control. Yields shown are the average across all barley or pea varieties grown.

Conclusions

Compared to equivalent (unfertilised) controls (at 100 % seeding rate), intercropping barley at 50 % rate gave comparable yields. In addition, the above 1 (15%) LER was a function of the pea yield. This potential could be increased further with better protection from pigeons, though whether this compromises barley yield, or yield qualities remains to be tested. Future work on the efficacy of barley-pea intercropping will assess the intercropped barley grains for their malting and distilling capacity, and a full financial cost: benefit analysis. Field trails in 2016 also aim to optimise the relative seeding rates and agronomy to match or exceed the yields of barley fertilised with inorganic N-fertiliser.

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