www.ias.is
https://doi.org/10.16886/IAS.2017.08 ICEL. AGRIC. SCI. 30 (2017), 73-76

Short communication

Effect of soil type on barley yields in Icelandic cultivar trials

Hrannar Smári Hilmarsson[1], Magnus Göransson[1,2], Jón Hallsteinn Hallsson[1], Þórdís Anna Kristjánsdóttir[1] and Jónatan Hermannsson[1]

[1]Agricultural University of Iceland, Keldnaholti, Árleyni 22, IS-112 Reykjavík, Iceland
[2]Department of Plant Sciences, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway.
E-mail (corresponding author): hrannar@lbhi.is

Key words: Barley, Andosol, Histosol, fertilizer, yield, thousand kernel weight, weight by volume.

INTRODUCTION

Spring barley (*Hordeum vulgare* L.) cultivar trials have been conducted in Iceland for decades, as described by Hilmarsson et al. (2017). At the Korpa experimental station in Reykjavik such trials were performed consecutively from 1991 to 2016.

The Andosols and Histosols (IUSS Working Group WRB 2006) at Korpa have been characterized by bulk densities of 0.69 to 0.93 and 0.37 to 0.48 kg l^{-1}, pH of 6.2 and 5.8, total of N 0.17 and 0.91%, and a water holding capacity of 0.89 and 2.09 g g $soil^{-1}$ respectively (Björnsson & Kristjánsdóttir 2003, Pálmason et al. 2003, Guðmundsson et al. 2006). The Andosols contained 3.6 t N ha^{-1} in the top 30 cm of the soil compared to 10.2 t N ha^{-1} in the Histosols, and the N release during the summer months of 2000 and 2001 was on average 32 kg ha^{-1} in the Andosols and 75 kg ha^{-1} in the Histosols (Pálmason et al. 2003).

In 1997 soil temperature was measured in barley fields at Korpa at a 10-cm depth throughout the growing season at 12 h intervals. In the first half of the season (before 11.7) the Andosol was on average 1°C warmer than the Histosol, while they were almost equally warm in the second half (Björnsson & Kristjánsdóttir 1998). That year, the average yield from Histosols was 16.6% higher than from Andosols, i.e. 3.62 and 2.94 t DM ha^{-1}, respectively.

Icelandic farmers grow barley on various soil types, and a better understanding of the interaction between soil type, genotype, yield, and maturity is therefore needed. Here we analyse the effect of soil type on yield and grain quality of different spring barley genotypes cultivated under Icelandic environmental conditions with the aim of shedding light on this interaction.

MATERIALS AND METHODS

In the years 1996–2004, 18 variety trials were carried out at the Korpa experimental station (64.15N; -21.75W; 30 m.a.s.l.). A total of 1821 plots were sown and harvested, 837 plots on Andosols and 984 on Histosols, though not all plots were sown or harvested on the same dates with a slight tendency for earlier harvesting on the Andosols. Most trials were laid out in three replicates, some in two and one in four replicates. Due to the high levels of available N in Histosols compared to Andosols, Histosols received a reduced amount of N, 60 kg N ha^{-1} (H^{60}), while Andosols received 90 kg N ha^{-1} (A^{90}). All plots received an amount of P and K expected to be non-limiting for these soils. Estimates of the parameters were calculated from plot values for yield, thousand kernel weight (TKW), and weight by volume (w/v) for 124 genotypes, but not all genotypes were represented in all trials; hence a mixed linear model was used for the unbalanced dataset. Calculations of residual maximum likelihood (reml) estimates of parameters were done using the lme4 package (Bates et al. 2015) and the ANOVA function in R-studio 1.0.136, where variety and soil type were considered fixed factors and replication nested within year was considered a random factor. A Pearson correlation test was done comparing reml estimates for the yield of the years 1996-2004 from each field and precipitation data collected at Korpa by the Icelandic Met Office (2017).

RESULTS

Reml estimates for yield in H^{60} ranged from 2.07–4.58 t DM ha^{-1} with a median of 3.56, and for A^{90} the range was 1.86–5.07 t DM ha^{-1} with a median of 3.42. The estimates for TKW ranged from 25.5–39.8 g in H^{60} with a median of 32.8 and from 25.7–43.3 with a median of 34.5 in A^{90}. The estimates for w/v ranged from 48.4–66.6 g in H^{60} with a median of 61.0 and from 46.4–69.9 with a median of 62.7 in A^{90}. The distribution of all three variables were wider in A^{90} (Figure 1).

The results showed a significant interaction between genotypes and the two different soil types in yield, TKW, and w/v (Figure 1). The factor that most significantly influenced yield was genotype (variety; Figure 1, Table 1).

Comparison of genotype performance in H^{60} and A^{90} for yield, TKW, and w/v showed the greatest variability in yield (Figure 1A) (r^2 = 0.31). The cultivar 'Artturi' yielded only 62% in A^{90} of that of H^{60}, in contrast to 'Cecilia' which yielded 51% more in A^{90} than in H^{60}. Popular 2-row cultivars in Iceland such as 'ISKria' were very stable, yielding only 1% more in A^{90} than H^{60}, and 'Filippa' yielded 8% more in A^{90} than in H^{60}. The correlation between precipitation and yield in either soil type was not significant (data not shown).

The genotypes showed less variability for TKW than for yield (r^2 = 0.64) (Figure 1B). For the TKW most genotypes performed better in A^{90} than in H^{60}. The TKW of 'Cecilia' was 28% higher in A^{90} than in H^{60}, whilst the Icelandic breeding line '265-2' performed 7% better in H^{60} than in A^{90}. 'ISKria' and 'Filippa' were also rather stable for TKW, and were 8% and 9% higher in A^{90} than in H^{60}, respectively.

The genotypes showed a higher weight by

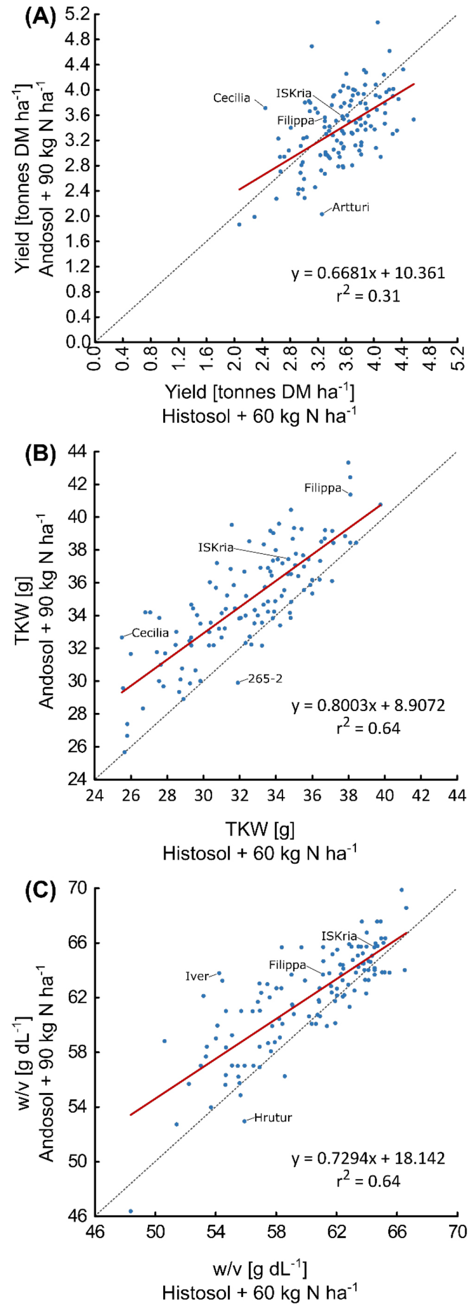

Figure 1: Scatterplots comparing least square means for genotypes cultivated in two different soil types. (A) Reml estimates for yield of 124 genotypes grown on A^{90} and H^{60} in tonnes DM ha^{-1}, (B) reml estimates for thousand kernel weight in grams and (C) reml estimates for weight by volume in g dL^{-1}.

Table 1. Analysis of Variance (ANOVA) of yield, thousand kernel weight (TKW), and weight by volume (w/v). Factors shown are genotype (variety), soil type and interaction between genotype and soil type.

Analysis of Variance for 'Yield'					
	SS	MS	DF	F	P
Variety	25550.4	207.7	123	6.71	< 2.2e-16
Soil type	547.3	547.3	1	17.69	2.752e-05
Var x Soil	7850.9	63.8	123	2.06	5.330e-10
Total SS	33948.6				
Analysis of Variance for 'TKW'					
	SS	MS	DF	F	P
Variety	17026.5	138.4	123	19.40	< 2.2e-16
Soil type	1736.6	1736.6	1	243.32	< 2.2e-16
Var x Soil	1396.9	11.4	123	1.59	7.741e-05
Total SS	20160				
Analysis of Variance for 'w/v'					
	SS	MS	DF	F	P
Variety	21532.1	175.1	123	23.58	< 2.2e-16
Soil type	1055.5	1055.5	1	142.20	< 2.2e-16
Var x Soil	1862.3	15.1	123	2.04	1.007e-09
Total SS	24449.9				

volume in the A^{90} than in H^{60} ($r^2 = 0.64$) (Figure 1C). The cultivar 'Iver' performed 18% better in A^{90} compared to H^{60} and the Icelandic breeding line 'Hrutur' had a 5% lower w/v in A^{90} than in H^{60}. 'Filippa' and 'ISKria' once again showed rather stable outputs, as they performed 4% and 2% better in A^{90} than in H^{60}, respectively.

DISCUSSION

Some genotypes seemed mostly unaffected by the soil type and gave a stable yield, such as the 2-row variety 'Filippa', which might explain its popularity amongst farmers in Iceland (Hilmarsson et al. 2017). A lot of the apparent interaction could be explained by two characteristics; firstly, very late maturing genotypes that give very low yield on Histosols (i.e. 'Iver', 'Cecilia') and secondly early maturing 6-row genotypes that tend to lose grain to the wind on Andosols but performed better and were less matured on Histosols (i.e. 'Artturi'). Less variability was seen in the quality of the grain, TKW (Figures 1B) and w/v (Figures 1C), than in yield. Interestingly, the genotypes generally produced heavier grain in the Andosol fields than in the Histosol fields. The interactive effects found between genotypes and soil types for yield, TKW, and w/v (Table 1) stressed the importance of cultivar choice for different soil types, but also suggest the possibility of targeted breeding for different soils.

Several reasons may explain the higher yields seen in H^{60} (Figure 1A). Histosols have a higher water holding capacity (Guðmundsson et al. 2006), which benefits the plants in dry summers; they not only have more N stored but likely other plant nutrients as well. However, Histosols warm up more slowly in the first half of the growing season (Björnsson & Kristjánsdóttir 1998), which could be due to their higher water content (Guðmundsson et al. 2006), which could lead to later heading dates. Furthermore, N that is mineralized from soils late in the growing season results in delayed maturity of the grain (Hermannsson 1999), benefiting the barley plants and leading to higher yields, at least in climatically favourable years. The warmer and drier A^{90} plots led to a higher TKW in most genotypes tested here (Figure 1B), which could be due to earlier heading and earlier maturity than in H^{60}.

It can be assumed that the nitrogen fertilizer applied (90 kg ha^{-1} N in Andosols, 60 kg ha^{-1} in Histosols) partly levelled off the differences in soil fertility between the two soil types, since more decaying organic matter in Histosols generally supplies the plants with more N (Pálmason et al. 2003). Precipitation could potentially have a larger effect on plants on Andosols as they could be more vulnerable to drought. However, the analyses did not show any correlation between yields and precipitation in the relatively wet climate at Korpa, where the average precipitation during the growing season from 1996-2004 was 298.4 mm. Another confounding factor in the analysis was the fact that in many cases barley was harvested earlier in A^{90} than in H^{60}.

The results presented here are of practical value to Icelandic farmers when selecting barley varieties for fields of different soil types, but the information on genotypes well suited to lower input of fertilizer might also be utilized in specialized low-input and organic systems, an aspect of agriculture that merits further attention in Icelandic agricultural research.

REFERENCES

Bates D, Maechler M, Bolker BM & Walker SC 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software* 67, 1–48. https://doi.org/10.18637/jss.v067.i01.

Björnsson H & Kristjánsdóttir ÞA 2003. Jarðræktarrannsóknir 2002. [Agricultural research report 2002]. *Fjölrit Rala* 213, 68p. [In Icelandic].

Björnsson H & Kristjánsdóttir ÞA 1998. Jarðræktarrannsóknir 1997. [Agricultural research report 1996]. *Fjölrit Rala* 189, 82p. [In Icelandic].

Guðmundsson J, Arnalds Ó & Óskarsson H 2006. Vatnsheldni mismunandi jarðvegsflokka. [Water holding capacity of different soil types]. *Fræðaþing landbúnaðarins* 2006, 362-364. [In Icelandic].

Hermannsson J 1999. Úr korntilraunum 1993-1998. [Barley trials 1993-1998]. *Ráðunautafundur* 1999, 54-61. [In Icelandic].

Hilmarsson HS, Göransson M, Lillemo M, Kristjánsdóttir ÞA, Hermannsson J & Hallsson JH 2017. An overview of barley breeding and variety trials in Iceland in 1987-2014. *Icelandic Agricultural Sciences* 30, 13-28. https://doi.org/10.16886/IAS.2017.02.

Icelandic Met Office 2017. Accessed 01.04.2017 at http://www.vedur.is.

IUSS Working Group WRB 2006. World reference base for soil resources. *World Soils Resources Reports* 103, 127p. FAO, Rome.

Pálmason F, Björnsson H & Hermannsson J 2003. Nýting niturs í kornökrum. [Nitrogen use in barley fields]. *Ráðunautafundur* 2003, 173-177. [In Icelandic].

Manuscript received 1 June 2017
Accepted 6 December 2017