Supplementary Material

# Supplementary Material S1. Details of *in situ* trials

## The in situ procedure

Each year, the straw of each genotype collected during DOMI trials was milled through a 200-mm laboratory hammer mill with a 3-mm screen (Christy and Norris, Ipswich, UK). Portions of milled straw weighing approximately 3.0 g of each genotype were precisely weighed into labelled polyester mesh bags. These bags were made from HS013 Dacron filter cloth with a declared pore size of 12 × 12 µm (Henry Simon Ltd, Stockport, UK) and were 50 mm wide and 250 mm long.

Immediately before inserting the next set of bags containing straw into the rumen, each bag was tightly attached to a nylon cord with a rubber band and soaked in warm water (38°C) for 2 minutes. If there were bags already inside the rumen they were removed, and the next set of soaked bags was inserted through the cannula without delay. Bags that had been removed were hand-washed in warm water for two minutes, dried at 65°C for 48 hours to stop microbial activity while minimizing heat damage to chemical constituents, and placed in a desiccator. The dried bags were weighed containing the straw residue, the residue was discarded, and the empty bags were reweighed. Dry matter loss (DML) was calculated from these weights and the initial weight of dry matter in the bag (see data analysis in the main text). The bags used to determine the DML of unincubated straw (‘zero-hour’ bags) were soaked, washed, dried, and weighed in the same manner as incubated bags.

## The cannulated sheep and their diets

The four cannulated Awassi sheep, mean weight 50 kg, were aged between 2 and 5 years. Before each year’s *in situ* trials, the sheep were allowed daytime access to a grassed exercise paddock and 1.0 kg/day/sheep of pelleted alfalfa (*Medicago sativa* L.) for at least 28 days. They were next housed indoors in individual pens and fed barley landrace straw supplemented with barley grain, cottonseed meal and a mineral-vitamin mixture for 14 days. On the final ten of these days, each sheep was offered 120% of its average straw intake on the previous three days, and the sheep’s mean pre-trial voluntary straw intake was calculated.

In the following four 21-day periods, each sheep was fed 80% of its mean pre-trial intake of barley landrace straw at 09:00 h. On top of the straw, the *Bar* diet was fed to two sheep and the *Mix* diet was fed to the other two. These diets were changed over between periods. In addition to a vitamin-mineral supplement, *Bar* contained 680 g of barley grain per kg of straw, and *Mix* contained 460 g of barley grain and 280 g of decorticated cottonseed meal per kg of straw (Table S1.1). The diets were approximately isocaloric, containing around 8.8 MJ/kg DM of metabolizable energy (M.E.) (Alderman and Cottrill 1993), but differed in total nitrogen concentration (9.4 g N/kg DM for *Bar* and 14.6 g N/kg DM for *Mix*).

## Design of the in situ trials

The trial diets were fed in four 21-day periods each year, and *in situ* incubations were performed in the last 14 days of each period. Eight polyester mesh bags containing samples of different straw genotypes were tested in each sheep in each period, and one sample of each genotype was tested in each sheep during the four periods, using a randomized alpha lattice design (SASS 1987). Bags (other than the ‘zero-hour’ bag) were incubated in the rumen according to an all-in, all-out schedule in which the incubation durations were synchronous for all sheep. The sequence of incubation times (6, 12, 18, 24, 36, 48, 72, and 120 hours) was randomized, with the restriction that bags were changed only during weekdays, at 8:00, 14:00, or 20:00 h. The number of possible sequences was approximately 700.

**Table S1.1. Calculated composition of diets fed during *in situ* trials**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name of diet or ingredient** | **Quantity fed, g/kg of  straw (air-dry basis)** | **Proportion  in the DM  of the diet, g/kg** | | | **Composition of ingredient or total ration** | | | | | | |
| **Measured total  Kjeldahl N ᵃ,  g/kg DM** | **Rumen-  degradability  of N, g/g ᵇ** | **Rumen-  degradable N,   g/kg DM** | **Metabolizable  energy (ME),  MJ/kg DM ᶜ** | **Fermentability  of ME, g/g ᵈ** | **Fermentable ME.  MJ/kg DM** | **Rumen-  degradable N, g/MJ  of fermentable ME ᵉ** |
| **The *Bar* diet** | | | | | | | | | | | |
| **Barley landrace straw** | **1000** | | **584** | | **4.76** | **0.667** | **3.17** | **6.37** | **0.922** | **5.87** | **0.54** |
| **Barley grain** | **680** | | **391** | | **16.82** | **0.860** | **14.47** | **13.25** | **0.955** | **12.65** | **1.14** |
| **Mineral-vitamin mixture** | **40** | | **25** | | **0.00** | **n/a** | **0.00** | **0.00** | **n/a** | **0.00** | **0.00** |
| ***Bar* diet, composition/kg DM** | | | **1000** | | **9.36** | **0.726** | **8.37** | **8.90** | **0.912** | **8.38** | **0.76** |
| **The *Mix* diet** | | | | | | | | | | | |
| **Barley landrace straw** | **1000** | | | **565** | ***As for*** | | | ***the* Bar *diet*** | | |  |
| **Barley grain** | **460** | | | **255** | ***As for*** | | | ***the* Bar *diet*** | | |  |
| **Cottonseed meal** | **280** | | | **156** | **48.60** | **0.715** | **34.73** | **11.10** | **0.793** | **8.80** | **3.95** |
| **Mineral-vitamin mixture** | **40** | | | **24** | ***As for*** | | | ***the* Bar *diet*** | | |  |
| ***Mix* diet, composition/kg DM** | | | | **1000** | **14.58** | **0.708** | **10.91** | **8.72** | **0.888** | **7.92** | **1.21** |
| **ᵃ N was equivalent to crude protein / 6.25 (Alderman & Cottrill 1993), analyzed in the laboratory as total Kjeldahl nitrogen.**  **ᵇ The degradability of N is assumed to be rp2 ∕ CP and the rumen CP outflow is assumed to be 0.02 g/hour, where rp2 denotes degradable protein and CP denotes crude protein (Tables 1a, 2a & 3a in Alderman & Cottrill 1993).**  **ᶜ The mean *in vitro* DOMD of white-seeded two-rowed landrace straws fed to the cannulated sheep was 0.411 g/g (S.E.M. 0.006), so that the metabolizable energy (ME) density, assumed to be 0.53 + 0.142 × *in vitro* DOMD, was 6.37 MJ/kg DM (equation #137 in Alderman & Cottrill 1993). The ME for barley grain and cottonseed meal was taken from the same source.**  **ͩ The fermentability of ME is fermentable ME (FME) divided by ME (Tables 1a, 2a & 3a in Alderman & Cottrill 1993).**  **ᵉ The potential yield of microbial N × 6.25 per MJ FME is assumed to be 7.0 + 6.0 × (1 −exp(−0.35 × feeding level)) = 1.40 g microbial N/MJ at maintenance (equation #34 in Alderman & Cottrill 1993).** | | | | | | | | | | | |

## Ammonia N measurement

Samples of rumen fluid for ammonium N measurement were taken immediately before feeding and six hours later. The samples were withdrawn using a 50-ml syringe attached to a polyethylene tube covered with a layer of cloth, acidified with an equal volume of 0.2 M hydrochloric acid, and frozen. After centrifugation of thawed samples, ammonium N was measured in Kjeltec apparatus. A 5-ml sample of supernatant was alkalinized with 10 ml of saturated sodium tetraborate in a digestion tube, steam-distilled into 5 ml of 1.0 M boric acid (H3BO3), and titrated with 0.01 M hydrochloric acid using an indicator containing bromocresol green and methyl red.

## Data analysis for the in situ trials (additional details)

The DML data for six bags were missing. Outlying values of raw *in situ* DML data were detected using full ANOVAs within year-by-incubation time combinations and were removed iteratively until the residual sum of squares ceased decreasing significantly (*P* >0.100). The distribution of DML values was tested for normality within each incubation time, both before and after the removal of outliers (Shapiro-Wilk *P* >0.050, Zaiontz, 2021).

The precision of *in situ* parameter estimates was assessed by comparing the values for the 32 genotypes calculated by two different pathways. In the pathway assumed to be the more accurate, the model was fitted to the whole-trial mean DML values for each genotype. In the other pathway, the model was first fitted to yearly mean DML values for each genotype, the results of which were next averaged by genotype. The sets of parameters for genotypes calculated by the two pathways were compared with each other by correlation. These correlations, all *P*<0.0001, were strongest for parameters *A* (*r* = +0.997) and *DMLp* (*r* = +0.992), and weakest for parameters *Lag* (*r* = +0.88) and *c* (*r* = +0.72).

# Supplementary Material S2. Basic statistics of trait data

**Table S2.1. Means by genotype and by year, with basic statistics, for dry matter loss *in situ* (DML) and four parameters derived from DML**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Incubation time or parameter →** | | **Dry matter loss *in situ* (DML) at (hours):** | | | | | | | | | | | | | | | | | | | | **Fitted parameters of dry matter loss *in situ*** | | | | | | |
| **0 h** | | **6 h** | | | **12 h** | | **18 h** | | **24 h** | | **36 h** | | **48 h** | | **72 h** | | **120 h** | | ***A*** | | ***DMLp*** | | ***c*** | ***Lag*** | ***DMLp*** | |
| ***Bar*** | ***Mix*** |
| **Unit of measurement →** | | ***g/g*** | | ***g/g*** | | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g*** | | ***g/g/h*** | ***hours*** | ***g/g*** | ***g/g*** |
| **RESULTS FOR GENOTYPES** | |  | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype group** | **Genotype ID** |  | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2p** | **1** | **0.110** | | **0.173** | | | **0.251** | | **0.266** | | **0.358** | | **0.452** | | **0.493** | | **0.564** | | **0.620** | | **0.111** | | **0.629** | | **0.031** | **3.36** | **0.626** | **0.640** |
| **2p** | **6** | **0.128** | | **0.190** | | | **0.266** | | **0.304** | | **0.383** | | **0.482** | | **0.523** | | **0.595** | | **0.639** | | **0.128** | | **0.648** | | **0.034** | **3.40** | **0.657** | **0.644** |
| **2p** | **8** | **0.105** | | **0.146** | | | **0.225** | | **0.255** | | **0.327** | | **0.416** | | **0.463** | | **0.538** | | **0.577** | | **0.105** | | **0.589** | | **0.033** | **4.37** | **0.614** | **0.571** |
| **2w** | **7** | **0.114** | | **0.166** | | | **0.265** | | **0.305** | | **0.381** | | **0.496** | | **0.554** | | **0.621** | | **0.660** | | **0.114** | | **0.670** | | **0.038** | **4.39** | **0.671** | **0.671** |
| **2w** | **18** | **0.116** | | **0.178** | | | **0.258** | | **0.299** | | **0.385** | | **0.485** | | **0.533** | | **0.605** | | **0.653** | | **0.116** | | **0.662** | | **0.034** | **3.54** | **0.667** | **0.658** |
| **2w** | **19** | **0.114** | | **0.179** | | | **0.258** | | **0.298** | | **0.375** | | **0.483** | | **0.534** | | **0.608** | | **0.660** | | **0.114** | | **0.674** | | **0.032** | **3.65** | **0.688** | **0.663** |
| **2w** | **24** | **0.116** | | **0.189** | | | **0.266** | | **0.299** | | **0.378** | | **0.474** | | **0.522** | | **0.601** | | **0.641** | | **0.116** | | **0.659** | | **0.032** | **2.81** | **0.674** | **0.644** |
| **2w** | **30** | **0.114** | | **0.163** | | | **0.238** | | **0.275** | | **0.353** | | **0.444** | | **0.486** | | **0.563** | | **0.618** | | **0.114** | | **0.629** | | **0.0310** | **3.96** | **0.644** | **0.617** |
| **2w** | **32** | **0.129** | | **0.209** | | | **0.283** | | **0.316** | | **0.407** | | **0.516** | | **0.548** | | **0.635** | | **0.671** | | **0.129** | | **0.679** | | **0.0359** | **3.65** | **0.700** | **0.679** |
| **2m** | **2** | **0.111** | | **0.159** | | | **0.234** | | **0.280** | | **0.358** | | **0.456** | | **0.502** | | **0.580** | | **0.629** | | **0.111** | | **0.641** | | **0.0325** | **4.25** | **0.652** | **0.632** |
| **2m** | **3** | **0.115** | | **0.159** | | | **0.240** | | **0.269** | | **0.350** | | **0.435** | | **0.480** | | **0.554** | | **0.607** | | **0.115** | | **0.616** | | **0.0316** | **4.03** | **0.623** | **0.614** |
| **2m** | **20** | **0.108** | | **0.165** | | | **0.247** | | **0.276** | | **0.359** | | **0.443** | | **0.487** | | **0.563** | | **0.620** | | **0.108** | | **0.627** | | **0.0316** | **3.40** | **0.644** | **0.619** |
| **2m** | **23** | **0.116** | | **0.187** | | | **0.269** | | **0.294** | | **0.367** | | **0.469** | | **0.519** | | **0.578** | | **0.638** | | **0.117** | | **0.641** | | **0.0330** | **3.14** | **0.659** | **0.637** |
| **2e** | **12** | **0.113** | | **0.167** | | | **0.242** | | **0.287** | | **0.351** | | **0.464** | | **0.517** | | **0.590** | | **0.649** | | **0.113** | | **0.663** | | **0.0305** | **3.79** | **0.669** | **0.661** |
| **2e** | **15** | **0.115** | | **0.175** | | | **0.253** | | **0.283** | | **0.370** | | **0.480** | | **0.528** | | **0.605** | | **0.658** | | **0.117** | | **0.673** | | **0.0319** | **4.14** | **0.682** | **0.670** |
| **2e** | **16** | **0.120** | | **0.172** | | | **0.253** | | **0.272** | | **0.361** | | **0.455** | | **0.503** | | **0.583** | | **0.628** | | **0.120** | | **0.646** | | **0.0314** | **3.80** | **0.662** | **0.633** |
| **2e** | **17** | **0.125** | | **0.171** | | | **0.254** | | **0.281** | | **0.357** | | **0.450** | | **0.495** | | **0.563** | | **0.610** | | **0.125** | | **0.619** | | **0.0331** | **4.06** | **0.624** | **0.619** |
| **2e** | **21** | **0.120** | | **0.212** | | | **0.286** | | **0.320** | | **0.402** | | **0.493** | | **0.541** | | **0.612** | | **0.654** | | **0.122** | | **0.655** | | **0.0390** | **3.21** | **0.672** | **0.662** |
| **2e** | **22** | **0.106** | | **0.140** | | | **0.225** | | **0.258** | | **0.342** | | **0.447** | | **0.478** | | **0.561** | | **0.619** | | **0.106** | | **0.628** | | **0.0317** | **4.93** | **0.632** | **0.626** |
| **2e** | **27** | **0.115** | | **0.151** | | | **0.219** | | **0.250** | | **0.325** | | **0.425** | | **0.458** | | **0.532** | | **0.579** | | **0.115** | | **0.593** | | **0.0313** | **4.83** | **0.611** | **0.576** |
| **6e** | **13** | **0.116** | | **0.152** | | | **0.228** | | **0.271** | | **0.349** | | **0.443** | | **0.495** | | **0.570** | | **0.620** | | **0.116** | | **0.632** | | **0.0328** | **4.98** | **0.637** | **0.630** |
| **6e** | **26** | **0.116** | | **0.163** | | | **0.242** | | **0.269** | | **0.343** | | **0.446** | | **0.491** | | **0.564** | | **0.611** | | **0.116** | | **0.624** | | **0.0319** | **4.08** | **0.630** | **0.622** |
| **6m** | **9** | **0.108** | | **0.152** | | | **0.230** | | **0.271** | | **0.337** | | **0.433** | | **0.480** | | **0.555** | | **0.604** | | **0.108** | | **0.619** | | **0.0316** | **4.03** | **0.624** | **0.610** |
| **6m** | **10** | **0.120** | | **0.183** | | | **0.258** | | **0.287** | | **0.367** | | **0.477** | | **0.517** | | **0.587** | | **0.629** | | **0.120** | | **0.640** | | **0.0335** | **3.61** | **0.647** | **0.641** |
| **6m** | **11** | **0.122** | | **0.172** | | | **0.245** | | **0.286** | | **0.352** | | **0.454** | | **0.497** | | **0.571** | | **0.617** | | **0.122** | | **0.629** | | **0.0321** | **3.95** | **0.634** | **0.627** |
| **6m** | **14** | **0.121** | | **0.170** | | | **0.244** | | **0.283** | | **0.354** | | **0.444** | | **0.486** | | **0.554** | | **0.597** | | **0.121** | | **0.605** | | **0.0334** | **3.85** | **0.606** | **0.607** |
| **6m** | **25** | **0.115** | | **0.154** | | | **0.228** | | **0.264** | | **0.338** | | **0.413** | | **0.466** | | **0.535** | | **0.589** | | **0.115** | | **0.603** | | **0.0308** | **4.21** | **0.601** | **0.601** |
| **6m** | **28** | **0.117** | | **0.158** | | | **0.233** | | **0.262** | | **0.351** | | **0.434** | | **0.480** | | **0.559** | | **0.606** | | **0.117** | | **0.617** | | **0.0317** | **4.54** | **0.636** | **0.606** |
| **62** | **4** | **0.107** | | **0.157** | | | **0.240** | | **0.268** | | **0.352** | | **0.433** | | **0.491** | | **0.549** | | **0.595** | | **0.107** | | **0.604** | | **0.0340** | **4.01** | **0.618** | **0.594** |
| **62** | **5** | **0.098** | | **0.162** | | | **0.232** | | **0.261** | | **0.336** | | **0.415** | | **0.447** | | **0.521** | | **0.572** | | **0.099** | | **0.573** | | **0.0344** | **3.51** | **0.582** | **0.583** |
| **2x** | **29** | **0.110** | | **0.186** | | | **0.266** | | **0.297** | | **0.379** | | **0.477** | | **0.529** | | **0.599** | | **0.649** | | **0.110** | | **0.659** | | **0.0326** | **2.72** | **0.666** | **0.659** |
| **2x** | **31** | **0.100** | | **0.168** | | | **0.252** | | **0.275** | | **0.350** | | **0.456** | | **0.494** | | **0.559** | | **0.614** | | **0.100** | | **0.621** | | **0.0326** | **2.86** | **0.633** | **0.616** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Mean** | | | **0.114** | | **0.170** | | | **0.248** | | **0.281** | | **0.359** | | **0.456** | | **0.501** | | **0.574** | **0.623** | | **0.115** | | **0.633** | | **0.032 8** | **3.85** | **0.643** | **0.629** |
| **Standard error of the mean (S.E.M.)** | | | **0.005 5** | | **0.014 3** | | | **0.014 2** | | **0.014 8** | | **0.013 2** | | **0.012 7** | | **0.012 5** | | **0.012 1** | **0.010 1** | | **0.005 5** | | **0.009 8** | | **0.001 7** | **0.657** | **0.011 4** | **0.011 3** |
| **Standard deviation between means (S.D.)** | | | **0.007 0** | | **0.016 6** | | | **0.016 9** | | **0.017 6** | | **0.019 5** | | **0.025 2** | | **0.026 9** | | **0.027 4** | **0.026 1** | | **0.007 0** | | **0.026 5** | | **0.001 9** | **0.576** | **0.027 4** | **0.028 0** |
| **Coefficient of variation (C.V.)** | | | **0.062** | | **0.098** | | | **0.068** | | **0.063** | | **0.054** | | **0.055** | | **0.054** | | **0.048** | **0.043** | | **0.062** | | **0.043** | | **0.058** | **0.150** | **0.043** | **0.044** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **RESULTS FOR YEAR** | | |  | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Year 1** | | | **0.115** | | **0.195** | | | **0.258** | | **0.296** | | **0.342** | | **0.449** | | **0.511** | | **0.573** | **0.635** | | **0.115** | | **0.655** | | **0.028** | **1.70** | **0.666** | **0.652** |
| **Year 2** | | | **0.112** | | **0.183** | | | **0.260** | | **0.309** | | **0.391** | | **0.492** | | **0.532** | | **0.605** | **0.661** | | **0.112** | | **0.660** | | **0.035** | **3.49** | **0.693** | **0.651** |
| **Year 3** | | | **0.106** | | **0.131** | | | **0.203** | | **0.241** | | **0.327** | | **0.420** | | **0.479** | | **0.556** | **0.603** | | **0.107** | | **0.621** | | **0.031** | **5.89** | **0.620** | **0.622** |
| **Year 4** | | | **0.124** | | **0.169** | | | **0.270** | | **0.277** | | **0.378** | | **0.463** | | **0.484** | | **0.563** | **0.593** | | **0.124** | | **0.597** | | **0.038** | **4.29** | **0.595** | **0.598** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Mean** | | | **0.114** | | **0.170** | | | **0.248** | | **0.281** | | **0.359** | | **0.456** | | **0.501** | | **0.574** | **0.623** | | **0.115** | | **0.633** | | **0.032 8** | **3.85** | **0.643** | **0.631** |
| **Standard error of means (S.E.M.)** | | | **0.001 9** | | **0.005 1** | | | **0.005 0** | | **0.005 2** | | **0.004 7** | | **0.004 5** | | **0.004 4** | | **0.004 3** | **0.003 6** | | **0.001 9** | | **0.003 5** | | **0.000 6** | **0.232** | **0.004 0** | **0.004 0** |
| **Standard deviation between means (S.D.)** | | | **0.007 5** | | **0.028 0** | | | **0.030 0** | | **0.029 6** | | **0.030 1** | | **0.030 1** | | **0.024 6** | | **0.021 7** | **0.030 9** | | **0.007 3** | | **0.030 1** | | **0.004 6** | **1.741** | **0.044 3** | **0.025 7** |
| **Coefficient of variation (C.V.)** | | | **0.065** | | **0.165** | | | **0.121** | | **0.105** | | **0.084** | | **0.066** | | **0.049** | | **0.038** | **0.050** | | **0.064** | | **0.048** | | **0.140** | **0.453** | **0.069** | **0.041** |
| ***C.V. for year / C.V. for genotype*** | | | ***1.06*** | | ***1.69*** | | | ***1.78*** | | ***1.69*** | | ***1.54*** | | ***1.19*** | | ***0.92*** | | ***0.79*** | ***1.19*** | | ***1.04*** | | ***1.14*** | | ***2.46*** | ***3.02*** | ***1.61*** | ***0.92*** |
|  | | | | | | | | | | | | | | | | | | | | | | | | **↑** | | | | |
| **Blue fonts denote cells containing calculations  within this Table** | | | | | |  | | | | | | | | | | | | | | **'Deviant' values of parameter DMLp are shaded: ‘high deviants’ are shaded green and double-underlined, and ‘low deviants’ are shaded pink and  *boxed .*** | | | | | | | | |

**Table S2.2. Means by genotype and by year, with basic statistics, for *in vivo*, crop yield, and laboratory-based traits**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trait and units of measurement →:** | | | **Organic matter intake of straw (g/day) ᵈ** | | | | | | | **Crop yields, air dry (t/ha) ᵃ** | | | | | | | **Laboratory analysis** | | | | | | | | | | |
| **Organic matter intake (OMI)** | **Digestible OM intake (DOMI)** | | | | | | **Grain** | | **Straw** | | | **Total biological** | | | **Total Ash** | | **Total Kjeldahl N** | | **NDF** | | **ADF** | **Ash of ADF** | **ADL ᵃ** | **DOMD *in vitro* ᵇ** |
| **Mean** | | **No  supplement** | | **With  supplement** | |
| ***t/ha*** | | ***t/ha*** | | | ***t/ha*** | | | ***g/kg DM*** | | ***g/kg DM*** | | ***g/kg DM*** | | ***g/kg DM*** | ***g/kg DM*** | ***g/kg DM*** | ***g/g DM*** |
| **RESULTS FOR GENOTYPES** | | |  | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype group** | | **Genotype ID** |  | | | | | | | | | | | | | | | | | | | | | | | | |
| **2p** | | **1** | **781.0** | | **410.6** | | **313.9** | | **494.0** | | **2.20** | | **3.02** | | | **5.50** | | | **120.8** | | **4.01** | | **789.6** | **462.2** | **38.5** | **70.7** | **0.370** |
| **2p** | | **6** | **881.5** | | **472.8** | | **379.7** | | **577.7** | | **2.51** | | **2.95** | | | **5.78** | | | **121.2** | | **4.28** | | **764.1** | **436.0** | **37.9** | **63.6** | **0.429** |
| **2p** | | **8** | **708.4** | | **371.1** | | **299.6** | | **435.7** | | **1.98** | | **3.01** | | | **5.24** | | | **107.6** | | **4.50** | | **787.7** | **468.4** | **32.4** | **67.4** | **0.369** |
| **2w** | | **7** | **768.7** | | **427.1** | | **335.9** | | **539.7** | | **2.37** | | **2.90** | | | **5.58** | | | **128.7** | | **5.81** | | **769.8** | **453.7** | **41.8** | **50.1** | **0.428** |
| **2w** | | **18** | **860.1** | | **482.9** | | **442.6** | | **529.3** | | **2.45** | | **2.68** | | | **5.45** | | | **132.8** | | **4.53** | | **764.7** | **449.5** | **42.2** | **72.0** | **0.412** |
| **2w** | | **19** | **837.6** | | **465.1** | | **369.7** | | **552.3** | | **2.27** | | **2.97** | | | **5.54** | | | **123.6** | | **4.29** | | **780.5** | **451.3** | **37.6** | **56.3** | **0.412** |
| **2w** | | **24** | **823.9** | | **459.3** | | **410.3** | | **494.4** | | **2.55** | | **2.95** | | | **5.83** | | | **131.0** | | **4.43** | | **779.7** | **455.2** | **45.5** | **61.8** | **0.408** |
| **2w** | | **30** | **781.1** | | **422.0** | | **394.8** | | **431.2** | | **2.15** | | **3.04** | | | **5.46** | | | **124.1** | | **4.50** | | **770.7** | **460.5** | **39.4** | **72.5** | **0.384** |
| **2w** | | **32** | **883.0** | | **485.3** | | **380.1** | | **556.8** | | **2.69** | | **2.97** | | | **6.00** | | | **129.4** | | **5.02** | | **758.2** | **432.5** | **42.5** | **62.9** | **0.423** |
| **2m** | | **2** | **793.4** | | **430.1** | | **407.6** | | **442.2** | | **2.65** | | **3.04** | | | **6.03** | | | **116.1** | | **4.22** | | **788.1** | **463.2** | **35.4** | **63.7** | **0.406** |
| **2m** | | **3** | **798.1** | | **440.5** | | **367.4** | | **520.0** | | **2.45** | | **3.17** | | | **5.94** | | | **117.3** | | **4.05** | | **780.6** | **459.8** | **38.3** | **66.4** | **0.385** |
| **2m** | | **20** | **750.9** | | **398.3** | | **311.3** | | **496.8** | | **2.42** | | **2.75** | | | **5.48** | | | **121.2** | | **3.94** | | **782.6** | **460.2** | **33.9** | **64.0** | **0.372** |
| **2m** | | **23** | **825.4** | | **460.0** | | **343.4** | | **578.0** | | **2.46** | | **2.78** | | | **5.57** | | | **132.4** | | **4.62** | | **758.4** | **440.6** | **42.7** | **63.2** | **0.392** |
| **2e** | | **12** | **818.5** | | **439.0** | | **360.9** | | **525.0** | | **2.69** | | **2.80** | | | **5.83** | | | **124.7** | | **4.12** | | **772.0** | **457.7** | **39.5** | **52.6** | **0.404** |
| **2e** | | **15** | **822.8** | | **437.6** | | **360.2** | | **530.1** | | **2.87** | | **3.32** | | | **6.56** | | | **123.0** | | **4.25** | | **778.0** | **441.8** | **38.3** | **66.6** | **0.417** |
| **2e** | | **16** | **845.3** | | **461.4** | | **369.5** | | **565.4** | | **2.79** | | **3.08** | | | **6.23** | | | **122.6** | | **4.25** | | **774.7** | **449.0** | **39.3** | **59.9** | **0.390** |
| **2e** | | **17** | **799.3** | | **421.8** | | **359.0** | | **459.2** | | **2.62** | | **3.19** | | | **6.15** | | | **126.9** | | **4.08** | | **769.2** | **462.6** | **40.0** | **68.3** | **0.413** |
| **2e** | | **21** | **813.3** | | **436.3** | | **347.9** | | **531.1** | | **2.67** | | **2.68** | | | **5.69** | | | **128.4** | | **4.70** | | **768.9** | **448.0** | **40.3** | **61.9** | **0.409** |
| **2e** | | **22** | **808.8** | | **449.3** | | **402.1** | | **502.1** | | **2.54** | | **2.92** | | | **5.78** | | | **119.0** | | **4.18** | | **779.3** | **454.1** | **37.2** | **61.9** | **0.405** |
| **2e** | | **27** | **780.9** | | **422.5** | | **328.8** | | **518.3** | | **2.58** | | **3.15** | | | **6.06** | | | **124.0** | | **4.32** | | **763.6** | **459.5** | **37.9** | **60.1** | **0.352** |
| **6e** | | **13** | **760.0** | | **417.8** | | **356.6** | | **482.9** | | **3.02** | | **2.91** | | | **6.31** | | | **113.9** | | **4.13** | | **784.7** | **466.3** | **36.9** | **61.7** | **0.377** |
| **6e** | | **26** | **743.9** | | **415.8** | | **352.2** | | **450.5** | | **3.04** | | **2.99** | | | **6.42** | | | **116.0** | | **4.20** | | **785.2** | **467.5** | **34.8** | **65.1** | **0.370** |
| **6m** | | **9** | **682.8** | | **360.0** | | **294.3** | | **443.8** | | **2.84** | | **2.89** | | | **6.09** | | | **137.7** | | **3.87** | | **775.8** | **455.3** | **47.8** | **54.0** | **0.390** |
| **6m** | | **10** | **757.7** | | **417.8** | | **338.8** | | **489.9** | | **2.59** | | **2.67** | | | **5.59** | | | **126.3** | | **4.14** | | **771.7** | **455.2** | **39.1** | **60.5** | **0.392** |
| **6m** | | **11** | **742.0** | | **393.3** | | **341.0** | | **438.2** | | **2.78** | | **3.02** | | | **6.16** | | | **120.0** | | **3.89** | | **771.6** | **452.2** | **37.3** | **70.8** | **0.378** |
| **6m** | | **14** | **752.6** | | **396.2** | | **323.3** | | **453.9** | | **2.32** | | **2.90** | | | **5.52** | | | **119.8** | | **3.92** | | **787.5** | **463.3** | **39.1** | **65.5** | **0.396** |
| **6m** | | **25** | **767.3** | | **413.0** | | **390.3** | | **418.5** | | **2.32** | | **2.97** | | | **5.59** | | | **121.5** | | **4.13** | | **775.2** | **470.0** | **38.9** | **70.8** | **0.382** |
| **6m** | | **28** | **721.2** | | **382.8** | | **345.6** | | **407.8** | | **2.99** | | **3.23** | | | **6.60** | | | **114.9** | | **3.90** | | **785.0** | **471.0** | **33.8** | **64.0** | **0.390** |
| **62** | | **4** | **792.6** | | **442.4** | | **403.1** | | **471.3** | | **2.45** | | **3.33** | | | **6.10** | | | **115.3** | | **4.78** | | **777.2** | **450.0** | **33.4** | **61.3** | **0.371** |
| **62** | | **5** | **727.1** | | **383.9** | | **317.5** | | **427.4** | | **2.00** | | **3.36** | | | **5.62** | | | **104.3** | | **4.29** | | **790.1** | **471.5** | **31.7** | **79.0** | **0.353** |
| **2x** | | **29** | **833.5** | | **474.6** | | **435.7** | | **490.9** | | **2.46** | | **2.81** | | | **5.58** | | | **132.9** | | **4.65** | | **764.2** | **451.8** | **42.1** | **70.1** | **0.415** |
| **2x** | | **31** | **771.4** | | **436.6** | | **393.7** | | **449.6** | | **1.95** | | **3.12** | | | **5.32** | | | **119.8** | | **4.91** | | **779.7** | **459.1** | **37.2** | **72.0** | **0.390** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Mean** | | | **788.6** | | **429.6** | | **361.8** | | **490.7** | | **2.52** | | **2.99** | | | **5.83** | | | **122.4** | | **4.34** | | **775.9** | **456.2** | **38.5** | **64.4** | **0.393** |
| **Standard error of the mean (S.E.M.)** | | | **63.86** | | **17.93** | | **28.10** | | **26.13** | | **0.316** | | **0.336** | | | **0.618** | | | **11.23** | | **0.870** | | **19.29** | **46.83** | **6.94** | **n/a** | **0.021 7** |
| **Standard deviation between means (S.D.)** | | | **48.24** | | **32.51** | | **37.62** | | **49.20** | | **0.286** | | **0.185** | | | **0.360** | | | **7.33** | | **0.402** | | **9.12** | **9.77** | **3.60** | **6.21** | **0.020 5** |
| **Coefficient of variation (C.V.)** | | | **0.061** | | **0.076** | | **0.104** | | **0.100** | | **0.113** | | **0.062** | | | **0.062** | | | **0.060** | | **0.092** | | **0.012** | **0.021** | **0.094** | **0.096** | **0.052** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **RESULTS FOR YEAR** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | **Year 1** | | **832.3** | | **470.5** | | **406.5** | | **535.3** | | **2.98** | | **3.49** | | | **6.86** | | | **95.7** | | **4.70** | | **740.5** | **411.9** | **20.4** | **64.4** | **no data** |
|  | **Year 2** | | **902.2** | | **503.0** | | **390.7** | | **616.9** | | **2.50** | | **2.51** | | | **5.34** | | | **75.7** | | **4.09** | | **770.3** | **437.3** | **28.8** | **no data** | **no data** |
|  | **Year 3** | | **687.9** | | **363.5** | | **294.7** | | **419.0** | | **1.68** | | **1.53** | | | **3.43** | | | **207.6** | | **3.38** | | **815.4** | **498.1** | **62.3** | **no data** | **0.354** |
|  | **Year 4** | | **731.9** | | **378.8** | | **355.2** | | **391.8** | | **2.91** | | **4.41** | | | **7.70** | | | **110.6** | | **5.20** | | **777.4** | **477.6** | **42.6** | **no data** | **0.433** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Mean** | | | **788.6** | | **429.0** | | **361.8** | | **490.7** | | **2.52** | | **2.99** | | | **5.83** | | | **122.4** | | **4.34** | | **775.9** | **456.2** | **38.5** | **64.4** | **0.393** |
| **Standard error of means (S.E.M.)** | | | **16.81** | | **11.30** | | **16.19** | | **17.97** | | **0.112** | | **0.119** | | | **0.218** | | | **3.97** | | **0.308** | | **6.82** | **16.56** | **2.45** | **n/a** | **0.007 7** |
| **Standard deviation between means (S.D.)** | | | **96.93** | | **68.31** | | **49.57** | | **104.61** | | **0.597** | | **1.239** | | | **1.873** | | | **58.56** | | **0.786** | | **30.83** | **38.90** | **18.31** | **no data** | **0.055 5** |
| **Coefficient of variation (C.V.)** | | | **0.123** | | **0.159** | | **0.137** | | **0.213** | | **0.237** | | **0.415** | | | **0.321** | | | **0.478** | | **0.181** | | **0.040** | **0.085** | **0.475** | **no data** | **0.141** |
| ***C.V. for year / C.V. for genotype*** | | | ***1.98*** | | ***2.10*** | | ***1.32*** | | ***2.13*** | | ***2.09*** | | ***6.70*** | | | ***5.20*** | | | ***7.99*** | | ***1.96*** | | ***3.38*** | ***3.98*** | ***5.08*** | ***no data*** | ***2.71*** |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Blue fonts denote cells containing calculations  within this Table** | | | |  | | | | | | | | | | **ᵃ ADL: 72% H2SO4 Lignin, in year 1 only** | | | | | | | | | | **ᵇ DOMD in vitro (Tilley & Terry 1963), years 3 and 4 only** | | | |

# Supplementary Material S3. Further statistics of trait data

**Table S3.1. Correlation coefficients (without bootstrapping), ANOVA, variance components, and heritability, for dry matter loss *in situ* (DML) and four parameters derived from DML**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Incubation time or parameter →** | **Dry matter loss *in situ* (DML) at (hours):** | | | | | | | | | | | | | | **Fitted parameters of dry matter loss *in situ*** | | | | | | | | |
| **0 h** | **6 h** | | | **12 h** | **18 h** | **24 h** | **36 h** | **48 h** | | **72 h** | | **120 h** | | ***A*** | ***DMLp*** | ***c*** | ***Lag*** | ***DMLp*** | | | | |
| ***Bar*** | | | ***Mix*** | |
| **Unit of measurement →** | ***g/g*** | ***g/g*** | | | ***g/g*** | ***g/g*** | ***g/g*** | ***g/g*** | ***g/g*** | ***g/g*** | | ***g/g*** | | | ***g/g*** | ***g/g*** | ***g/g/h*** | ***hours*** | ***g/g*** | | | ***g/g*** | |
| **RESULTS FOR GENOTYPES** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with DOMI *in vivo*** | **+0.350** | **+0.561** | | | **+0.615** | **+0.585** | **+0.681** | **+0.691** | **+0.674** | **+0.665** | | **+0.700** | | | **+0.351** | **+0.682** | **+0.199** | **−0.372** | **+0.686** | | | **+0.649** | |
| ***P*(Pearson *r* with DOMI *in vivo*)** | **0.050** | **0.001** | | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.049** | **<0.0001** | **0.274** | **0.036** | **<0.0001** | | | **<0.0001** | |
| **S.E. of Pearson *r* with DOMI *in vivo*** | **0.157 4** | **0.126 6** | | | **0.116 0** | **0.122 0** | **0.101 5** | **0.099 1** | **0.103 1** | **0.105 1** | | **0.097 0** | | | **0.157 3** | **0.101 1** | **0.170 1** | **0.155 0** | **0.100 2** | | | **0.108 7** | |
| **Pearson *r*, based on bootstrapped values** | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with DOMI *in vivo*** | **+0.337** | **Not  calculated** | | | **+0.483** | **Not  calculated** | **+0.584** | **Not  calculated** | **+0.627** | **+0.586** | | **+0.619** | | | **+0.285** | **+0.616** | **+0.186** | **−0.270** | **Not  calculated** | | | **Not  calculated** | |
| ***P*(Pearson *r* with DOMI *in vivo*)** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.006** | **<0.0001** | **0.103** | **0.002** |
| **S.E. of Pearson *r* with DOMI *in vivo*** | **0.0724** | **0.0977** | **0.0645** | **0.0539** | **0.0567** | | **0.0494** | | | **0.1059** | **0.0561** | **0.1436** | **0.0834** |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with *in situ* *DMLp*** | **+0.438** | **+0.639** | | | **+0.722** | **+0.796** | **+0.822** | **+0.914** | **+0.937** | **+0.966** | | **+0.988** | | | **+0.448** | **[1]** | **+0.260** | **−0.314** | **+0.967** | | | **+0.969** | |
| ***P*(Pearson *r* with *in situ* *DMLp*)** | **0.012** | **<0.0001** | | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.010** | **n/a** | **0.151** | **0.080** | **<0.0001** | | | **<0.0001** | |
| **S.E. of Pearson *r* with *in situ DMLp*** | **0.146 6** | **0.111 0** | | | **0.091 3** | **0.071 3** | **0.063 6** | **0.032 9** | **0.024 8** | **0.013 6** | | **0.004 9** | | | **0.145 1** | **n/a** | **0.165 9** | **0.161 1** | **0.013 2** | | | **0.012 7** | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with ADF** | **−0.462** | **−0.670** | | | **−0.706** | **−0.691** | **−0.724** | **−0.764** | **−0.723** | **−0.713** | | **−0.709** | | | **−0.481** | **−0.680** | **−0.364** | **+0.352** | **−0.714** | | **−0.652** | | |
| ***P*(Pearson *r* with ADF)** | **0.008** | **<0.0001** | | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.005** | **<0.0001** | **0.040** | **0.048** | **<0.0001** | | **<0.0001** | | |
| **S.E. of Pearson *r* with ADF** | **0.143 0** | **0.104 1** | | | **0.095 5** | **0.099 0** | **0.091 0** | **0.080 2** | **0.091 0** | **0.093 6** | | **0.094 6** | | | **0.140 2** | **0.101 7** | **0.155 8** | **0.157 2** | **0.093 5** | | **0.108 1** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with Kjeldahl N (TKN)** | **−0.067** | **+0.315** | | | **+0.484** | **+0.467** | **+0.472** | **+0.502** | **+0.529** | **+0.464** | | **+0.407** | | | **−0.057** | **+0.359** | **+0.650** | **−0.189** | **+0.399** | | **+0.352** | | |
| ***P*(Pearson *r* with TKN)** | **0.717** | **0.079** | | | **0.005** | **0.007** | **0.006** | **0.003** | **0.002** | **0.007** | | **0.021** | | | **0.755** | **0.044** | **<0.0001** | **0.301** | **0.024** | | **0.048** | | |
| **S.E. of Pearson *r* with TKN** | **0.175 5** | **0.161 0** | | | **0.139 8** | **0.142 4** | **0.141 6** | **0.136 9** | **0.132 3** | **0.142 7** | | **0.150 6** | | | **0.175 6** | **0.156 4** | **0.108 4** | **0.170 8** | **0.151 7** | | **0.157 2** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with grain yield** | **+0.507** | **+0.074** | | | **+0.027** | **+0.101** | **+0.129** | **+0.189** | **+0.222** | **+0.285** | | **+0.261** | | | **+0.505** | **+0.317** | **−0.059** | **+0.348** | **+0.295** | | **+0.283** | | |
| ***P*(Pearson *r* with grain yield)** | **0.003** | **0.689** | | | **0.884** | **0.583** | **0.481** | **0.301** | **0.222** | **0.114** | | **0.150** | | | **0.003** | **0.077** | **0.747** | **0.051** | **0.101** | | **0.117** | | |
| **S.E. of Pearson *r* with grain yield** | **0.136 1** | **0.175 3** | | | **0.176 0** | **0.174 6** | **0.173 6** | **0.170 8** | **0.168 7** | **0.163 8** | | **0.165 8** | | | **0.136 3** | **0.160 9** | **0.175 6** | **0.157 6** | **0.162 9** | | **0.164 0** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with straw yield** | **−0.234** | **−0.371** | | | **−0.397** | **−0.514** | **−0.414** | **−0.454** | **−0.466** | | **−0.450** | | **−0.466** | | **−0.225** | **−0.443** | **−0.234** | **0.297** | | **−0.398** | | | **−0.455** |
| ***P*(Pearson *r* with straw yield)** | **0.198** | **0.037** | | | **0.025** | **0.003** | **0.018** | **0.009** | **0.007** | | **0.010** | | **0.007** | | **0.216** | **0.011** | **0.198** | **0.098** | | **0.024** | | | **0.009** |
| **S.E. of Pearson *r* with straw yield** | **0.167 9** | **0.155 0** | | | **0.151 9** | **0.134 8** | **0.149 7** | **0.144 3** | **0.142 4** | | **0.144 9** | | **0.142 4** | | **0.168 5** | **0.145 8** | **0.167 9** | **0.162 7** | | **0.151 8** | | | **0.144 0** |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **ANOVA MEAN SQUARES** | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype (31 D.F.)** | **0.000 199** | **0.001 096** | | | **0.001 139** | **0.001 233** | **0.001 527** | **0.002 550** | **0.002 886** | | **0.002 999** | | **0.002 721** | | **0.000 198** | **0.002 806** | **0.000 014** | **1.327** | | **0.002 860** | | | **0.003 120** |
| **Year (3 D.F.)** | **0.001 782** | **0.025 014** | | | **0.028 874** | **0.028 017** | **0.028 940** | **0.029 040** | **0.019 342** | | **0.015 129** | | **0.030 627** | | **0.001 715** | **0.028 974** | **0.000 673** | **97.022** | | **0.052 137** | | | **0.019 354** |
| **Genotype-by-year (93 D.F.)** | **0.000 120** | **0.000 818** | | | **0.000 804** | **0.000 873** | **0.000 702** | **0.000 648** | **0.000 625** | | **0.000 590** | | **0.000 411** | | **0.000 119** | **0.000 382** | **0.000 012** | **1.725** | | **0.000 524** | | | **0.000 514** |
| ***Residual mean square error  (RMSE, >100 D.F.)*** | ***0.000 056*** | ***0.000 221*** | | | ***0.000 506*** | ***0.000 515*** | ***0.000 580*** | ***0.000 646*** | ***0.000 510*** | | ***0.000 331*** | | ***0.000 459*** | | ***After genotype, year and genotype-by-year mean squares had been accounted for, no degrees of freedom remained*** | | | | | | | | |
| ***Genotype-by-year interaction / RMSE*** | ***2.14*** | ***3.70*** | | | ***1.59*** | ***1.70*** | ***1.21*** | ***1.00*** | ***1.23*** | | ***1.78*** | | ***0.90*** | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype variance ratio (*Fgeno*)** | **1.66** | | **1.34** | | **1.42** | **1.41** | **2.18** | **3.93** | **4.62** | **5.08** | | **6.61** | | | **1.66** | **7.34** | **1.14** | **0.77** | **5.46** | | **6.07** | | |
| **Crop year variance ratio** | **14.85** | | **30.58** | | **35.91** | **32.08** | **41.23** | **44.81** | **30.97** | **25.64** | | **74.44** | | | **14.37** | **75.78** | **55.50** | **56.24** | **99.45** | | **37.67** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype *P*-value** | **0.034** | | **0.143** | | **0.103** | **0.105** | **0.002** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.033** | **<0.0001** | **0.305** | **0.795** | **<0.0001** | | **<0.0001** | | |
| **Year *P*-value** | **<0.0001** | | **<0.0001** | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **VARIANCE COMPONENTS AND BROAD-SENSE HERITABILITY ᵃ** | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype** | **0.000 020** | | **0.000 070** | | **0.000 084** | **0.000 090** | **0.000 206** | **0.000 476** | **0.000 565** | **0.000 602** | | **0.000 577** | | | **0.000 020** | **0.000 606** | **0.000 000 4** | **0.00** | **0.000 584** | | **0.000 652** | | |
| **Year** | **0.000 052** | | **0.000 756** | | **0.000 877** | **0.000 848** | **0.000 882** | **0.000 887** | **0.000 585** | **0.000 454** | | **0.000 944** | | | **0.000 050** | **0.000 894** | **0.000 021** | **298.10** | **0.001 613** | | **0.000 589** | | |
| **Genotype-by-year (=Error)** | **0.000 120** | | **0.000 818** | | **0.000 804** | **0.000 873** | **0.000 702** | **0.000 648** | **0.000 625** | **0.000 590** | | **0.000 412** | | | **0.000 119** | **0.000 382** | **0.000 012** | **1.73** | **0.000 524** | | **0.000 514** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Broad-sense heritability (*h*²)** | **0.141** | | **0.078** | | **0.094** | **0.093** | **0.227** | **0.423** | **0.475** | **0.505** | | **0.584** | | | **0.142** | **0.613** | **0.035** | **0.000** | **0.527** | | **0.559** | | |
| **S.E. of *h²*** | **0.089 6** | | **0.083 5** | | **0.085 2** | **0.085 1** | **0.095 3** | **0.096 0** | **0.093 3** | **0.091 3** | | **0.084 0** | | | **0.089 7** | **0.080 5** | **0.078 2** | **0.073 3** | **0.089 5** | | **0.086 6** | | |
| **1-tailed *P*-value for *h*²** | **0.063** | | **0.177** | | **0.138** | **0.140** | **0.012** | **<0.0001** | **<0.0001** | **<0.0001** | | **<0.0001** | | | **0.062** | **<0.0001** | **0.330** | ***c*. 0.500** | **<0.0001** | | **<0.0001** | | |
| **Lower 90% confidence limit of *h*²** | **0.013** | | **–0.039** | | **–0.026** | **–0.026** | **0.087** | **0.273** | **0.326** | **0.358** | | **0.444** | | | **0.014** | **0.478** | **–0.073** | **–0.147** | **0.381** | | **0.417** | | |
| **Upper 90% confidence limit of *h*²** | **0.310** | | **0.240** | | **0.258** | **0.257** | **0.400** | **0.585** | **0.629** | **0.654** | | **0.717** | | | **0.311** | **0.740** | **0.189** | **0.069** | **0.672** | | **0.698** | | |
|  | | | | | | | | | | | | | | | | | | | | | | | |
| **Blue fonts denote cells containing calculations  from data within this Table or Table S2.1** | | | | **ᵃ Variance components have been calculated from  genotype-by-year data, n = 128** | | | | | | | | | |  | | | | | | | | | |

**Table S3.2. Correlation coefficients (without bootstrapping), ANOVA, variance components and heritability for *in vivo*, crop yield, and laboratory-based traits**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Trait and unit of measurement →** | **Voluntary intake (g/day)** | | | | | | | | **Crop yields, air dry** | | | | | | | **Laboratory analysis of samples taken during voluntary intake (*in vivo*) trials** | | | | | | | | | | | | | |
| **Organic matter intake (OMI)** | | **Digestible OMI (DOMI)** | | | | | | **Grain** | | **Straw** | | | **Total biological** | | **Total Ash** | | **Total  Kjeldahl N** | | **NDF** | | | **ADF** | | **Ash of ADF** | | **ADL ᵃ** | | **DOMD  *in vitro* ᵇ** |
| **Mean** | | | **No  supplement** | | **With  supplement** |
| ***t/ha*** | | ***t/ha*** | | | ***t/ha*** | | ***g/kg DM*** | | ***g/kg DM*** | | ***g/kg DM*** | | | ***g/kg DM*** | | ***g/kg DM*** | | ***g/kg DM*** | | ***g/g DM*** |
| **RESULTS FOR GENOTYPES** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with DOMI *in vivo*** | **+0.956** | **[1]** | | | **+0.748** | | **+0.736** | | **+0.018** | **−0.212** | | | **−0.095** | | **+0.424** | | **+0.419** | | **−0.574** | | | **−0.698** | | **+0.350** | | **Not  enough  data** | | **+0.604** | |
| ***P*(Pearson *r* with DOMI *in vivo*)** | **<0.0001** | **n/a** | | | **<0.0001** | | **<0.0001** | | **0.922** | **0.243** | | | **0.607** | | **0.016** | | **0.017** | | **0.001** | | | **<0.0001** | | **0.049** | | **<0.001** | |
| **S.E. of Pearson *r* with DOMI *in vivo*** | **0.016 1** | **n/a** | | | **0.081 7** | | **0.085 1** | | **0.176 1** | **0.169 3** | | | **0.174 8** | | **0.148 4** | | **0.149 1** | | **0.124 1** | | | **0.097 4** | | **0.157 4** | | **0.118 3** | |
| **Pearson *r*, based on bootstrapped values** |  |  | | |  | |  | |  |  | | |  | |  | |  | |  | | |  | |  | |  | |  | |
| **Pearson *r* with DOMI *in vivo*** | **0.703** | **n/a** | | | **Not  calculated** | | **Not  calculated** | | **Not  calculated** | **Not  calculated** | | | **Not  calculated** | | **0.390** | | **0.390** | | **−0.467** | | | **−0.545** | | **Not  calculated** | | **Not  calculated** | | **0.374** | |
| ***P*(Pearson *r* with DOMI *in vivo*)** | **<0.0001** | **n/a** | | | **<0.0001** | | **0.007** | | **<0.0001** | | | **<0.0001** | | **<0.001** | |
| **S.E. of Pearson *r* with DOMI *in vivo*** | **0.093 9** | **n/a** | | | **0.071 8** | | **0.148 5** | | **0.108 6** | | | **0.105 0** | | **0.095 8** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with parameter *DMLp*** | **+0.682** | **+0.682** | | | **+0.408** | | **+0.657** | | **−0.148** | **+0.275** | | | **+0.008** | | **−0.084** | | **+0.095** | | **−0.210** | | | **−0.146** | | **-0.182** | | **+0.302** | | **−0.034** | |
| ***P*(Pearson *r* with parameter *DMLp*)** | **<0.0001** | **<0.0001** | | | **0.021** | | **<0.0001** | | **0.418** | **0.128** | | | **0.965** | | **0.648** | | **0.604** | | **0.248** | | | **<0.0001** | | **0.318** | | **0.093** | | **<0.0001** | |
| **S.E. of Pearson *r* with parameter *DMLp*** | **0.099 2** | **0.099 2** | | | **0.154 8** | | **0.1056** | | **0.172 8** | **0.164 7** | | | **0.176 1** | | **0.175 1** | | **0.174 8** | | **0.169 5** | | | **0.172 9** | | **0.171 1** | | **0.162 3** | | **0.176 0** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with ADF** | **−0.741** | **−0.701** | | | **−0.285** | | **−0.788** | | **−0.169** | **0.239** | | | **−0.028** | | **−0.566** | | **−0.383** | | **0.710** | | | **[1]** | | **−0.473** | | **0.279** | | **−0.612** | |
| ***P*(Pearson r with ADF)** | **<0.0001** | **<0.0001** | | | **0.114** | | **<0.0001** | | **0.356** | **0.187** | | | **0.878** | | **0.001** | | **0.031** | | **<0.0001** | | | **n/a** | | **0.006** | | **0.122** | | **<0.001** | |
| **S.E. of Pearson r with ADF** | **0.083 7** | **0.094 3** | | | **0.1706** | | **0.0705** | | **0.171 9** | **0.167 5** | | | **0.176 0** | | **0.125 7** | | **0.153 7** | | **0.094 4** | | | **n/a** | | **0.141 4** | | **0.164 3** | | **0.116 6** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with Kjeldahl N (TKN)** | **+0.315** | **+0.428** | | | **+0.273** | | **+0.342** | | **−0.299** | **−0.076** | | | **−0.307** | | **+0.238** | | **[1]** | | **−0.415** | | | **−0.383** | | **+0.202** | | **−0.186** | | **+0.370** | |
| ***P*(Pearson *r* with TKN)** | **0.079** | **0.015** | | | **0.131** | | **0.055** | | **0.097** | **0.680** | | | **0.088** | | **0.189** | | **n/a** | | **0.018** | | | **0.031** | | **0.268** | | **0.309** | | **0.037** | |
| **S.E. of Pearson *r* with TKN** | **0.167 3** | **0.151 7** | | | **0.1719** | | **0.1640** | | **0.162 6** | **0.175 3** | | | **0.161 8** | | **0.167 6** | | **n/a** | | **0.149 6** | | | **0.153 7** | | **0.170 0** | | **0.170 9** | | **0.155 2** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with grain yield** | **+0.054** | **+0.039** | | | **+0.007** | | **+0.125** | | **[1]** | **−0.073** | | | **+0.859** | | **+0.206** | | **−0.299** | | **−0.140** | | | **−0.169** | | **+0.180** | | **−0.415** | | **+0.172** | |
| ***P*(Pearson *r* with grain yield)** | **0.771** | **0.833** | | | **0.968** | | **0.495** | | **n/a** | **0.691** | | | **<0.0001** | | **0.258** | | **0.097** | | **0.445** | | | **0.356** | | **0.324** | | **0.018** | | **0.345** | |
| **S.E. of Pearson *r* with grain yield** | **0.185 2** | **0.185 4** | | | **0.1857** | | **0.1828** | | **n/a** | **0.175 3** | | | **0.052 0** | | **0.169 7** | | **0.162 6** | | **0.173 2** | | | **0.171 9** | | **0.171 3** | | **0.149 7** | | **0.171 7** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pearson *r* with straw yield** | **−0.173** | **−0.215** | | | **−0.045** | | **−0.327** | | **−0.073** | **[1]** | | | **+0.448** | | **−0.551** | | **−0.076** | | **+0.350** | | | **+0.239** | | **−0.463** | | **+0.307** | | **−0.315** | |
| ***P*(Pearson *r* with straw yield)** | **0.344** | **0.238** | | | **0.805** | | **0.067** | | **0.691** | **n/a** | | | **0.010** | | **0.001** | | **0.680** | | **0.049** | | | **0.187** | | **0.008** | | **0.088** | | **0.079** | |
| **S.E. of Pearson *r* with straw yield** | **0.180 1** | **0.177 2** | | | **0.1853** | | **0.1658** | | **0.175 3** | **n/a** | | | **0.145 0** | | **0.128 4** | | **0.175 3** | | **0.157 4** | | | **0.167 5** | | **0.142 9** | | **0.161 8** | | **0.16 10** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **ANOVA MEAN SQUARES** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype (31 D.F.)** | **33 040** | **15 018** | | | **9 987** | | **15 297** | | **1.496** | **0.613** | | | **2.442** | | **860.5** | | **2.581** | | **1 330** | | | **1 527** | | **207.5** | | **77.1  *(31 D.F.)*** | | **0.002 231  *(31 D.F.)*** | |
| **Year (3 D.F. unless stated)** | **839 124** | **376 515** | | | **135 008** | | **258 248** | | **11.40** | **49.16** | | | **112.20** | | **439 020.3** | | **79.064** | | **121 654** | | | **193 738** | | **42 891.9** | | **No  data** | | **0.263 551  *(1 D.F.)*** | |
| **Genotype-by-year  (93 D.F. unless stated)** | **16 311** | **7 473** | | | **5 602** | | **6 484** | | **0.400** | **0.451** | | | **1.526** | | **243.5** | | **1.413** | | **667** | | | **409** | | **91.5** | | **0.000 930  *(31 D.F.)*** | |
| ***Residual mean square error  (RMSE, >100 D.F.)*** | ***10 542  (642 D.F.)*** | ***4 767   (642 D.F.)*** | | | ***5 018   (143 D.F.)*** | | ***4 132   (386 D.F.)*** | | ***0.188  (80 D.F.)*** | ***0.230  (80 D.F.)*** | | | ***0.766  (80 D.F.)*** | | ***93.2  (372 D.F.)*** | | ***1.461  (372 D.F.)*** | | ***607  (372 D.F.)*** | | | ***308  372 D.F.)*** | | ***42.9  (372 D.F.)*** | | ***62.0  (31 D.F.)*** | | ***0.000 537  (122 D.F.)*** | |
| ***Genotype-by-year interaction / RMSE*** | ***1.55*** | ***1.57*** | | | ***1.12*** | | ***1.57*** | | ***2.13*** | ***1.96*** | | | ***1.99*** | | ***2.61*** | | ***0.97*** | | ***1.10*** | | | ***1.33*** | | ***2.13*** | | ***n/a*** | | ***1.73*** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype variance ratio (*Fgeno*)** | **2.03** | **2.01** | | | **1.78** | | **2.36** | | **3.74** | **1.36** | | | **1.60** | | **3.53** | | **1.83** | | **2.00** | | | **3.73** | | **2.27** | | **No  data** | | **2.40** | |
| **Year variance ratio** | **51.45** | **50.39** | | | **24.10** | | **39.83** | | **130.7** | **499.9** | | | **337.3** | | **1803.08** | | **55.94** | | **182.50** | | | **473.55** | | **468.73** | | **283.29** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype *P*-value** | **0.005** | **0.006** | | | **0.018** | | **<0.0001** | | **<0.0001** | **0.132** | | | **0.044** | | **<0.0001** | | **0.014** | | **0.006** | | | **<0.0001** | | **0.001** | | **No  data** | | **0.009** | |
| **Year *P*-value** | **<0.0001** | **<0.0001** | | | **<0.0001** | | **<0.0001** | | **<0.0001** | **<0.0001** | | | **<0.0001** | | **<0.0001** | | **<0.0001** | | **<0.0001** | | | **<0.0001** | | **<0.0001** | | **<0.0001** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **VARIANCE COMPONENTS AND BROAD-SENSE HERITABILITY ᶜ** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Genotype** | **1 334** | **581** | | | **604** | | **1308.4** | | **0.060** | **0.006** | | | **0.048** | | **38.6** | | **0.073** | | **41.5** | | | **69.9** | | **7.2** | | **No  data** | | **0.000 225** | |
| **Year** | **9 271** | **4 611** | | | **2 356** | | **10804.3** | | **0.353** | **1.711** | | | **3.496** | | **3 427.9** | | **0.607** | | **945.2** | | | **1 510.4** | | **334.4** | | **0.003 071** | |
| **Genotype-by-year (=Error)** | **3 971** | **1 814** | | | **3 244** | | **4447.6** | | **0.087** | **0.115** | | | **0.325** | | **60.9** | | **0.353** | | **166.7** | | | **102.3** | | **22.9** | | **0.000 393** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Broad-sense heritability (*h*²)** | **0.251** | **0.243** | | | **0.157** | | **0.227** | | **0.407** | **0.048** | | | **0.130** | | **0.388** | | **0.171** | | **0.199** | | | **0.406** | | **0.241** | | **No  data** | | **0.364** | |
| **S.E. of *h²*** | **0.096 3** | **0.096 0** | | | **0.090 9** | | **0.095 3** | | **0.096 6** | **0.079 8** | | | **0.088 6** | | **0.097 1** | | **0.092 0** | | **0.093 8** | | | **0.096 6** | | **0.095 9** | | **0.089 9** | |
| ***P*-value for *h*² (1-tailed)** | **0.007** | **0.008** | | | **0.047** | | **0.012** | | **<0.0001** | **0.277** | | | **0.077** | | **0.0002** | | **0.036** | | **0.021** | | | **0.0001** | | **0.009** | | **0.0002** | |
| **Lower 90% confidence limit of *h*²** | **0.067** | **0.065** | | | **0.032** | | **0.111** | | **0.256** | **-0.036** | | | **0.003** | | **0.237** | | **0.038** | | **0.063** | | | **0.255** | | **0.099** | | **0.110** | |
| **Upper 90% confidence limit of *h*²** | **0.377** | **0.374** | | | **0.334** | | **0.427** | | **0.570** | **0.244** | | | **0.297** | | **0.554** | | **0.342** | | **0.372** | | | **0.570** | | **0.414** | | **0.611** | |
|  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Blue fonts denote cells containing calculations  within this Table or Table S2.2** | | | | **ᵃ ADL (72% H2SO4 Lignin),  measured in year 1 only** | | | | | | | | **ᵇ DOMD *in vitro* (Tilley & Terry 1963),  measured in years 3 and 4 only** | | | | | | | | | **ᶜ Variance components have been calculated from  genotype-by-year data, n = 128 (or 64 for DOMD)** | | | | | | | | |