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Effects of sugar beet root morphology and genotype on root damage and Tissue Integrity

Sugar losses in storage are mainly attributed to weak root tissues that damage easily and accelerate the leaching of cell solutes and respiration. Currently, there is no information on sugar beet tissue strength among recommended genotypes and environments in the UK. Specifically, the aims of this experiment were to 1) identify extreme sugar beet genotypes for tissue damage susceptibility and resilience, 2) identify morphological factors that affect a genotype's resilience to root breakage, 3) identify textural properties that affect resilience to root breakage 4) study the effect of delayed harvesting on textural properties and resilience to tissue damage. Sugar beet roots were sampled from field experiments at Bracebridge, Lincolnshire and Fotheringhay, Northamptonshire during 2019, 2020 and 2021 seasons. The experiment was laid in a randomised complete block design with eight genotypes from the 2019 recommended list and three replications.

Tissue properties were assessed post-harvest using a texture analyser and a rotating drum. Root tip damage was significantly different ($p<0.05$) among the genotypes while surface damage was only affected by site ($p<0.001$) (**Figure 1**). Root tip diameter after damage correlated to tissue compression, root width, length, and root weight. Surface damage negatively correlated with puncture resistance. Puncture resistance decreased from the crown to the tip and compression resistance was lowest on the root's central than peripheral and the middle. Our results suggest that genotype and morphology form part of the key factors in minimising tissue damage. Scheduling of harvesting was also seen to be a factor affecting compression suggesting that root maturity contributes towards tissue texture.

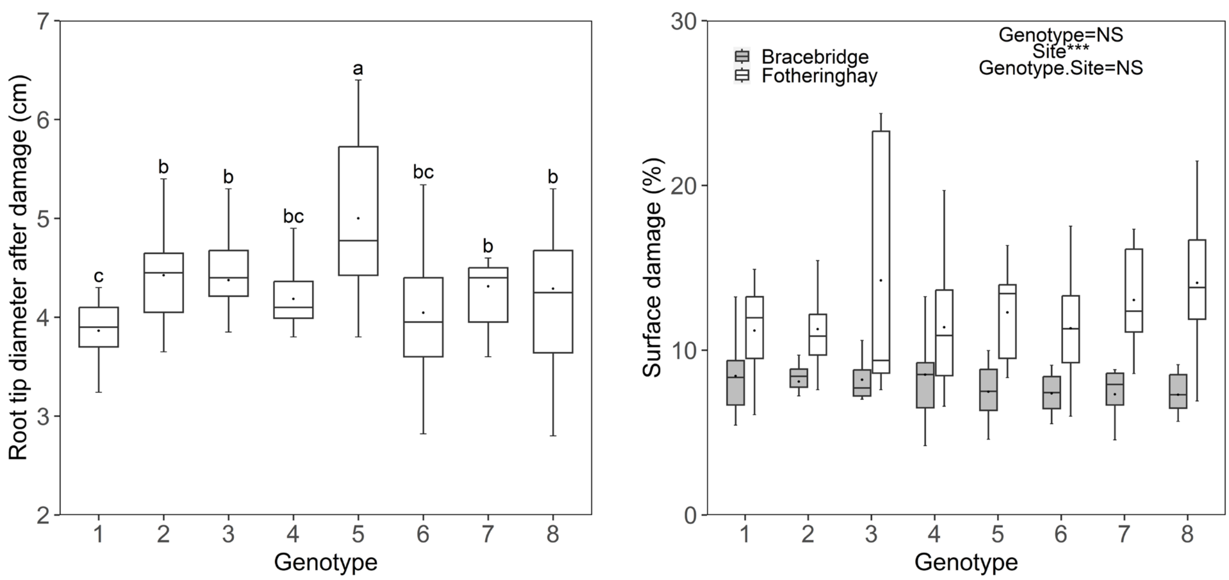

Figure 1: Root tip and surface tissue damage for eight sugar beet genotypes sampled in 2019, 2020 and 2022 at Bracebridge, Lincolnshire and Fotheringhay, Northamptonshire.

Effects of water and temperature at harvest on root damage and tissue integrity

Sugar beet root damage promotes sucrose losses of circa 0.1 - 0.4 % day^{-1} in storage. There is limited information on how temperature and water status at harvest affect root response to damage. Experiments in 2020, 2021 and 2022 investigated the effects of the two factors on root resilience to damage and tissue strength. Sugar beet were grown in potato boxes and plastic tubs in a field at Harper Adams University (HAU) and later transferred into a polytunnel at physiological maturity. Water and temperature treatments were imposed for seven weeks in the polytunnel and three days after harvesting, respectively. Temperature levels were imposed by storing the roots in cold rooms at 3 and 10 ºC while water status involved irrigating to field capacity and no irrigation. Results show that temperatures did not have an influence on any of the variables collected. However, high soil water status prior to harvesting increased relative water content (RWC) ($p<001$) which significantly increased root tissue frailness and damage by reducing puncture and compression resistance. RWC is positively correlated to surface damage (R^2 = 0.43) and root tip damage (R^2 = 0.42). Root tip damage was negatively correlated with resistance to compression while surface damage was negatively correlated with tissues resistance to puncture (**Figure 2**). We conclude that harvesting temperatures over the range of 3 - 10 ºC are not an issue of concern in sugar beet damage and optimisation of root tissue strength must carefully consider soil water status prior to harvest.

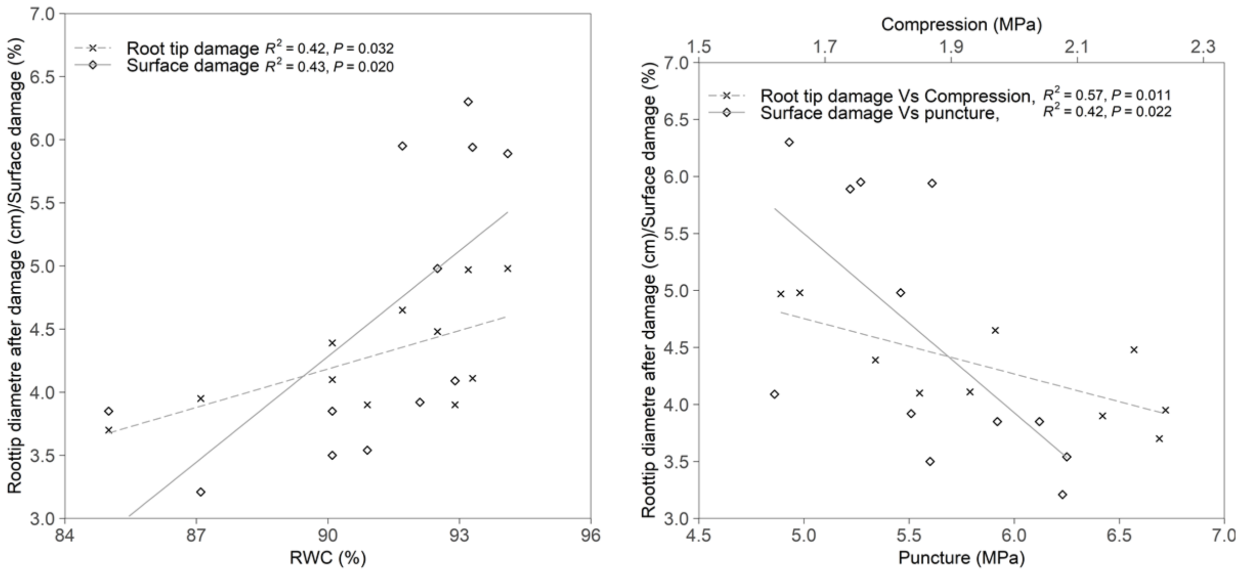

Figure 2: Relationship between sugar beet root/surface damage with root tissue's relative water content and textural properties (puncture and compression)

Effects of calcium (Ca) and boron (B) foliar application on root damage, quality and tissue integrity

B and Ca are directly linked to tissue strength in other crops like carrots, most sugar beet studies focused on their contribution to yield and yield components. There is little or no information on how their deficiency or toxicity affects root tissue strength and quality in sugar beet. The study hypothesised that 1) B affects sugar beet root tissue damage susceptibility, 2) B affects sugar beet root textural properties, 3) B affects sugar beet root quality, 4) Ca affects sugar beet root tissue damage susceptibility 5) Ca affects sugar beet root textural properties and 6) Ca affects sugar beet root quality. The trials were planted at the Morley Agricultural Foundation farm (tMAF) in Norfolk during the 2021 and 2022 seasons. The two trials (B and Ca trials) were planted separately in randomised complete block designs with three replicates each. For the B trial, YaraVita BORTRAC 150 (Yara fertilizer, Pocklington, UK) was applied at the six-leaf stage (SLS), 4 weeks after SLS and 8 weeks after SLS using a rate 0, 1 and 2 L ha^{-1} per application. While for the Ca trial, Omex CalMax® Ultra (East Riding Horticulture Ltd, Sutton Upon Derwent, UK) was applied at SLS and 4, 8, 12 and 16 weeks after SLS at a rate 0, 1 and 2 L ha^{-1} per application. In both trials two weak genotypes identified from previous variety trials were studied.

5 L ha^{-1} foliar Ca application reduced surface damage but did not affect root tip diameter after damage (**Figure 3**). Ca application reinforced root tissues' ability to resist puncture when applied during a season characterised by well-distributed rainfall. However, root quality was not affected by the Ca application. B did not affect root tissue damage, however a 6 L ha^{-1} application of B enhanced root tissue's resistance to compression. These results suggest that at tMAF, a 5 L ha^{-1} Ca foliar application is agronomically important when optimising tissue damage than B.

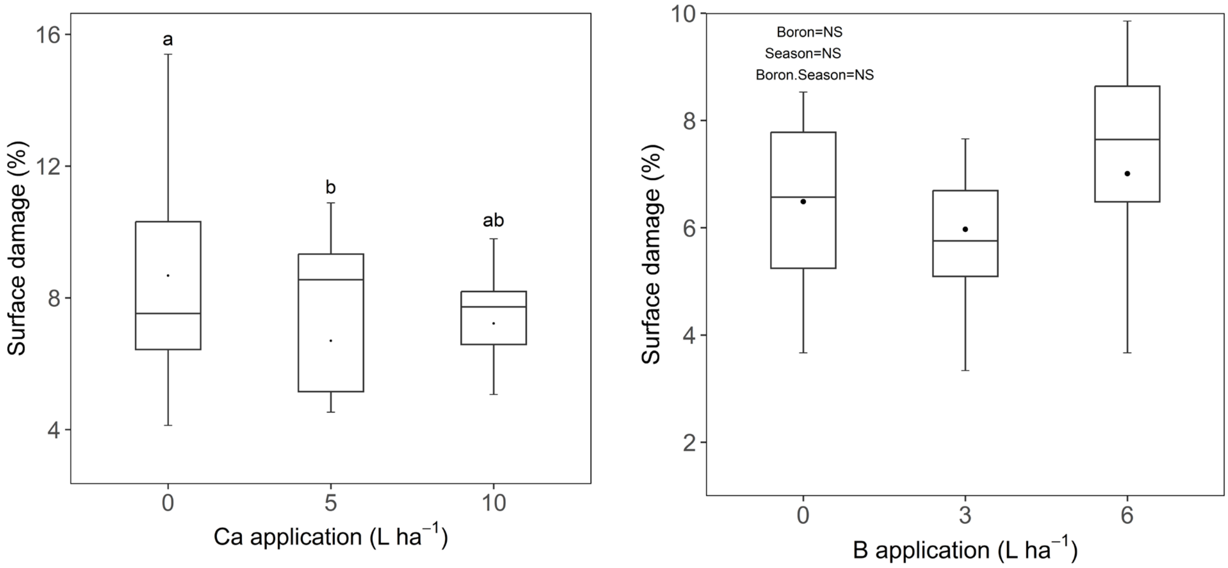

Figure 3: Sugar beet root tissue response to surface damage when boron or calcium was applied at the Morley Agricultural Foundation farm in Norfolk.