Grower Summary

Asparagus: Sustainable soil management for stand longevity and yield optimization

Year 2 Annual Report 2020

Project title:	**Asparagus: Sustainable soil management for stand longevity and yield optimization**
Project number:	FV 450a
Project leader:	Dr Rob Simmons, Cranfield University
Report:	Year 2 Annual Report, September 2020
Previous report:	FV 450a Year 1 Annual Report FV 450 Final Report
Key staff:	Lucie Maskova and Dr Lynda Deeks
Location of project:	Gatsford, Ross-on-Wye
Industry Representative:	Phil Langley Sandfield Farms
Date project commenced:	01/03/2018
Date project completed (or expected completion date):	31/05/2021

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headlines

- The impact of soil management practices on asparagus production (two varieties, Gijnlim and Guelph Millenium) has been monitored annually since 2016.
- Significant effects of zero tillage, ridging, shallow-soil disturbance, compost, mulch and companion crops on asparagus yield, root architecture and interrow wheeling soil compaction have been observed and will continue to be monitored as the crop moves into the phase of peak commercial production.
- Soil profile maps of root biomass derived from asparagus fields across the UK have enabled growers to see the potential risk of cultivations such as sub-soiling and annual ridging causing root damage in their crops.

Background

Conventional operations associated with UK asparagus production, i.e. tillage, spraying and harvesting, can result in progressive and severe compaction of all inter-bed wheelings. In addition, research has demonstrated that root damage associated with annual re-ridging has a major impact on stand longevity and productivity, and increases the susceptibility to crown and root rots caused by *Phytophthora* and *Fusarium* species. Both root damage and crown and root rots contribute significantly to yield decline.

Further, compaction of wheelings leads to a significant reduction in infiltration resulting in an increased risk of surface water ponding and on sloping land, run-off generation and erosion. In turn, surface water ponding and/or erosion compromises field operations by restricting foot and vehicular traffic, and water ponding in furrows increases the risk of crown and root rots leading to yield decline.

The long-term field trials established under this project are evaluating a range of best management practices to prevent and/or mitigate compaction, improve soil structural status in asparagus wheelings and facilitate long-term profitability of asparagus production. The experimental trials are comparing shallow soil disturbance (SSD) and mulch attenuation options, cover/companion cropping, and zero-tillage options against conventional practice. A further objective is to increase the relevance of potential best management practices by critically evaluating the asparagus root system architecture associated with the wider UK asparagus grower land bank and relevant cropping practices.

Summary

In April 2016 two replicated field experiments were established at Gatsford Farm, Ross-on-Wye. For full detail of the treatments investigated and results to date refer to the following reports: FV 450 Final Report (2018) and FV 450a Year 1 report (2019).

Experiment 1 (48 experimental plots) is restricted to Gijnlim which represents 70% of UK field grown asparagus.

Experiment 1: Treatment descriptions

Variety	Treatment description	Re-ridging
Gijnlim	Companion Crop – rye	R
Gijnlim	Companion Crop – rye	NR
Gijnlim	Companion Crop – mustard	R
Gijnlim	Companion Crop – mustard	NR
Gijnlim	PAS 100 compost SSD	R
Gijnlim	PAS 100 compost SSD	NR
Gijnlim	Straw Mulch SSD	R
Gijnlim	Straw Mulch SSD	NR
Gijnlim	Bare soil SSD	R
Gijnlim	Bare soil SSD	NR
Gijnlim	Conventional Practice	R
Gijnlim	Zero-tillage	NR

Annual re-ridging (R) or Zero-ridging (NR). Shallow soil disturbance (SSD). Treatments highlighted in green are included in Experiment 2.

Experiment 2 compares varietal differences in root development/architecture and root profile distribution as affected by sub-soiling treatments for two widely grown varieties, Gijnlim and Guelph Millennium.

Experiment 2: Treatment descriptions

Variety	Treatment description	Re-ridging
Gijnlim	Bare soil SSD	R
Gijnlim	Bare soil SSD	NR
Gijnlim	Conventional Practice	R
Gijnlim	Zero-tillage	NR
Guelph Millennium	Bare soil SSD	R
Guelph Millennium	Bare soil SSD	NR
Guelph Millennium	Conventional Practice	R
Guelph Millennium	Zero-tillage	NR

Annual re-ridging (R) or Zero-ridging (NR). Shallow soil disturbance (SSD). Treatments highlighted in green are included from Experiment 1.

The timing of treatment applications, root coring, yield monitoring and soil structural assessments are indicated in Figure A.

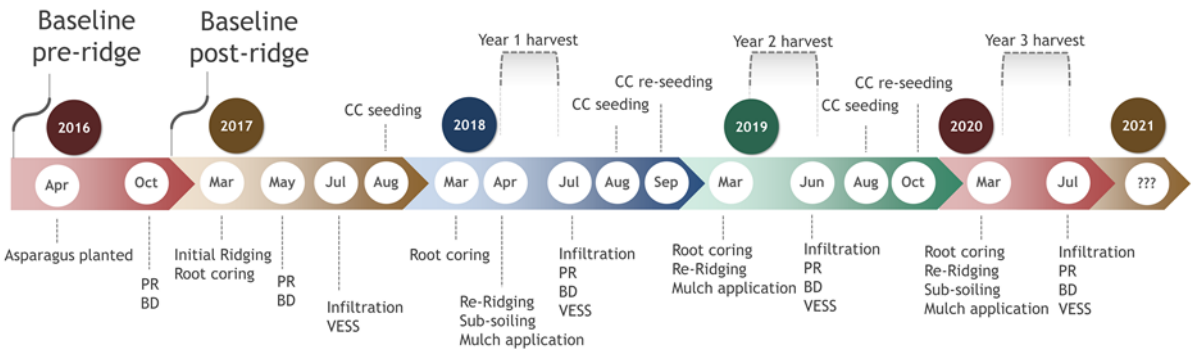

Figure A. FV 450 and FV 450a project timeline

Impact of treatments on asparagus yield

Experiment 1

- The PAS 100 compost treatments (ridged and non-ridged in combination with shallow soil disturbance) were associated with a 20% uplift in asparagus yield as compared to conventional practice and rye non-ridged treatments. Conventional practice is defined as annual re-ridging with no shallow soil disturbance applied to interrow wheelings. (Figure B)
- The rye non-ridged treatment continues to be associated with a 23% reduction in yield as compared to the rye ridged treatment.

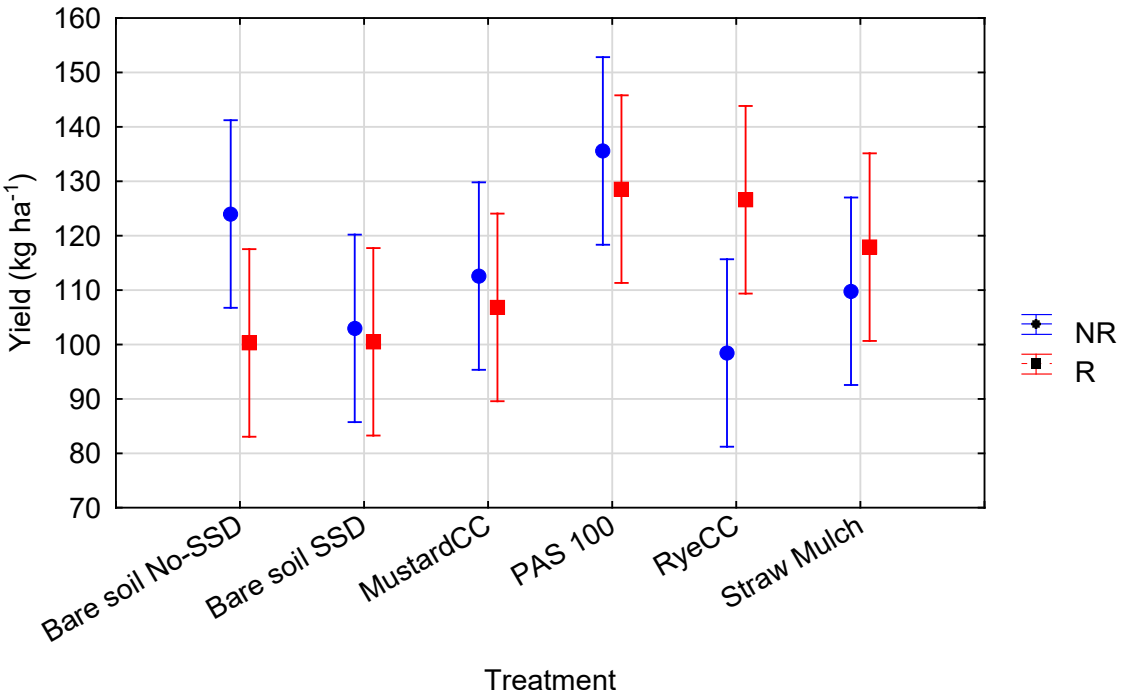

Figure B. Differences in 2020 Gijnlim yield (kg ha^{-1}) between Experiment 1 treatments. Vertical bars denote 0.95 confidence intervals.

- In 2020, (in contrast to 2018 and 2019) no significant difference in yield was observed between the comparable Gijnlim and Guelph Millennium treatments.

Experiment 2

- As observed in 2019, for both Gijnlim and Guelph Millennium, annual re-ridging associated with conventional practice was associated with a 20-24% reduction in yield as compared with the equivalent zero-tillage treatments. This may in part corroborate previous research showing that that annual re-ridging causes root damage and yield reductions.

Impact of treatments on storage root soluble carbohydrate (CHO) levels

Experiment 1

- Despite some clear yield differences, there was no effect of treatments on root CHO values in either 2019 or 2020.

Experiment 2

- The 2020 results follow the 2018 and 2019 findings that asparagus storage root CHO values for Guelph Millennium are significantly higher than the equivalent for Gijnlim, irrespective of treatment.

Impact of treatments on mitigating interrow wheeling compaction

In this project, penetrative resistance (PR) is used as a measure of soil compaction, with higher PR values indicative of higher levels of soil compaction.

- Conventional practice (defined as annual re-ridging with no shallow soil disturbance applied to interrow wheelings) was associated with significantly higher PR from 0.0-0.2 m depth as compared to all other bare soil treatments. In contrast, significantly lower PR values across the soil profile from the zero-tillage treatment indicated less soil compaction as compared to all other bare soil treatments.
- In both 2019 and 2020, companion cropping did not significantly affect PR as compared with conventional practice. This was unexpected as the companion crops were based on previous studies, expected to bioremediate soil structure.
- In 2020, PR was significantly reduced in the interrow wheelings to 0.25 m depth for all shallow soil disturbance treatments. Furthermore, the straw mulch and PAS 100 compost treatments (applied in conjunction with shallow soil disturbance) resulted in significantly less compaction than conventional practice to greater than 0.5 m depth.
- In 2020, infiltration rates in all treatments subject to shallow soil disturbance were classified as "Very Rapid" (>500 mm h^{1}) and were significantly higher than for conventional practice ("Moderate", 23.2 mm h^{-1}).
- The results suggest that the combination of mulch application (either PAS 100 Compost or straw) to interrow wheeling and shallow soil disturbance significantly reduces deep seated compaction and increases infiltration. This has implications for runoff and erosion control as well as soil moisture re-charge.

Impact of treatments on root architecture

Experiment 1

- Significant differences in whole profile root mass density (RMD) were observed between the zero tillage and conventional practice treatments. This was due to significant differences in RMD at 0.15 – 0.30 m depth, 0.3, 0.6 and 0.9 m from the crown zero line. These differences amount to between a 48-98% increase in RMD associated with the zero-tillage treatment. This indicates that annual re-ridging damages storage roots. However, to date, no significant reduction in yield or increase in disease incidence has been observed in relation to this treatment.

Experiment 2

- Guelph Millennium is associated with a shallower rooting tendency as compared with Gijnlim. For the zero-tillage treatment, which essentially allows the asparagus roost to grow undisturbed, Guelph Millennium is associated with 66-100% higher RMD at 0.0 – 0.15 m depth at 0.3 and 0.6 m from the crown zero line, as compared with Gijnlim.

Potential root damage associated with sub-soiling and ridging operations

Experiment 1 and 2

- Across all treatments, sub-soiling (shallow soil disturbance) in interrow wheelings could potentially damage up to 5% of the total root biomass under a range of tine configurations used at an operating depth of 300 mm. Annual ridging operations also have the potential to damage up to 5% of total root biomass.

Wider grower landbank:

Root samples collected from asparagus fields in 2019-2020 were used to create field-specific 'root heat maps' showing root biomass at different depths and distances from the crown. These maps can be used by growers to determine the risk of root damage following different cultivation practices in individual fields. As an example of this, maps for 3- and 11-year old crops of Gijnlim, respectively for two fields from Grower E, indicate the following:

- Gijnlim planted as A crowns grown on 1.80 m centres, aged 2-6 years old would be associated with damage to <2% of total root biomass under all tine configurations investigated by Niziolomski, et al. (2016) to an operating depth of 300 mm (Figure C). The root heat map also suggests that re-ridging has the potential to damage on average 5-8% of total root biomass.
- In contrast, for 11-year old Guelph Millennium planted on 1.5 m centres, there is potential for 8-11% of storage root total biomass to be damaged when using the winged with shallow leading tine, winged tine and modified para-plough investigated by Niziolomski, et al. (2016) to a 300 mm operating depth (Figure D). Approximately, 2-5 % of total root biomass could potentially be damaged using the narrow tine and narrow with shallow leading tine configurations investigated. With re-ridging, there is the potential to damage 11-14% of total root biomass. This is due to both the age of stand and shallower rooting habit of Guelph Millennium.

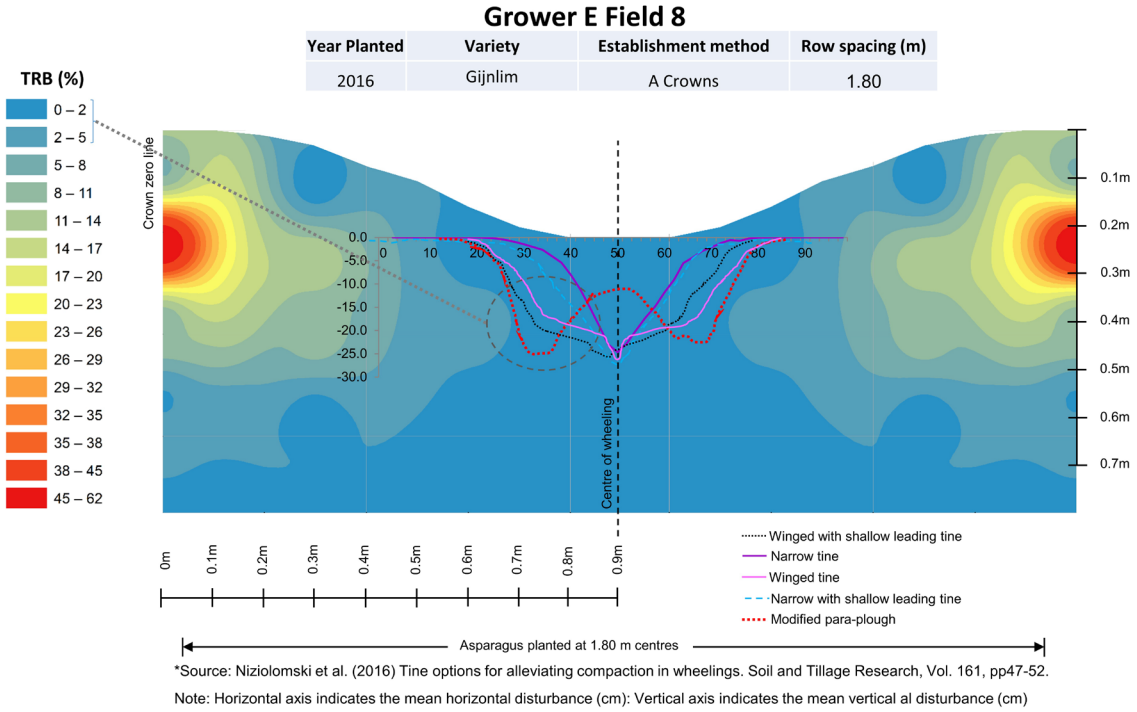

Figure C. Grower E total root biomass: root map for 3-year old Gijnlim A-crowns. Potential root damage associated with sub-soiling operations to 300 mm depth.

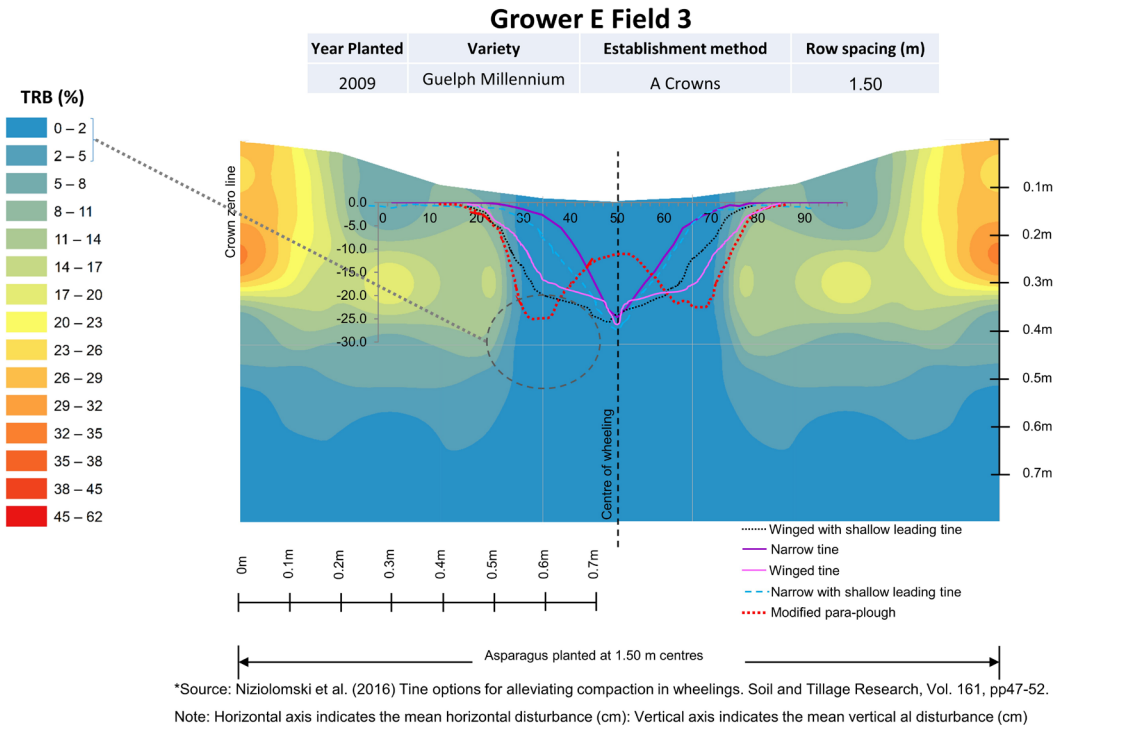

Figure D. Grower E total root biomass: root map for 11-year old Guelph Millennium A-Crowns. Potential root damage associated with sub-soiling operations to 300 mm depth.

Financial Benefits

It is envisaged that this project will provide information on the state of asparagus soils and

provide focused, practical and robust guidance on how to identify and alleviate compaction and water-logging in asparagus wheelings, thereby reducing the risk of asparagus decline, increasing asparagus yields and farm profitability, while minimising environmental impact. In addition, this project will also provide research outcomes that can feed directly into policy discussions associated with the Environmental Land Management scheme (ELMS) scheme such that asparagus growers can receive 'financial reward in return for delivering environmental benefits'.

Over a 10-year cropping cycle, asparagus decline largely attributed to *Fusarium* and *Phythophtora* species can result in up to 60% loss of stand amounting to up to £16M in lost revenue. A 10% reduction in yield losses due to asparagus decline would amount to a saving in the region of £160,000 to UK asparagus growers per year.

Action Points

This is the 4th year of this long-term replicated field trial now continued under FV 450a. However, key action points are beginning to emerge.

Cereal rye (*Cereale secale*) is grown as a companion crop to mitigate run-off and erosion over the autumn and winter periods. This is in line with the Farming Rules for Water and the expected requirements of the Environmental Land Management scheme (ELMS) scheme. There is now robust evidence that when rye (*Cereale secale*) is grown as a companion crop and ridging cannot be undertaken the following spring that a significant (*circa* 20%) yield reduction can be expected. However, if ridging can be undertaken no yield penalty is observed as compared with conventional practice or zero-tillage.

The results continue to support the recommendation that in order to prevent storage root damage through re-ridging or subsoiling operations, growers should undertake exploratory root profile distribution surveys prior to commencing re-ridging and/or sub-soiling operations. Guidance on how to undertake asparagus root coring can be found at https://www.youtube.com/watch?v=Lms3GfRgiXM.

Reference

Niziolomski, J.C., Simmons, R.W., Rickson, R.J. and Hann, M.J. (2016). Tine options for alleviating compaction in wheelings. Soil and Tillage Research, 161, 47-52.