FIG report: Deeper Rooting 2019

FIG members

Participating Farmers:
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The Concept & Hypotheses

The concept underlying the formation of this FIG comes from the recognition that, for most soils, crops need to explore the soil fully to at least 1m depth to provide sufficient water to achieve uninhibited growth and thus potential yields, yet measures of rooting in recent years have shown that cereal & oilseed crops to often have insufficient roots below about 40 cm. It is known that cereal roots struggle to penetrate strong soils at depth, and are reliant on pre-existing fissures, cracks and channels from previous roots, mechanical loosening or earthworms to reach deeper into the subsoil.

Deep burrowing (anecic) earthworms create deep vertical burrows up to 2m deep that improve soil porosity, aeration & water infiltration, and also provide channels for root development through soils which are otherwise too strong for crop roots to penetrate. If anecic earthworms and their activity can be increased in the soil, more channels should be created and the greater the opportunity for roots to go deeper. However, recent work by Jackie Stroud (@wormscience) has shown that anecic earthworms in many arable fields are now rare or absent. This is due to intensive cultivations destroying burrows and there being a lack of decomposing plant litter as a food source on the soil surface. Because anecic earthworms have a relatively slow reproductive cycle the populations are unable to recovery quickly following soil disturbance.

Management systems which increase organic matter inputs and reduce soil disturbance should therefore promote the recovery of anecic earthworm populations, by improving food supplies and reducing burrow disturbance.

The Deeper Rooting FIG was formed following the YEN Ideas Lab in June 2018, with farmers volunteering to get involved via twitter discussions. They wanted to test whether reducing cultivations and applying manure could have a substantial effect on anecic earthworm numbers, on depth of rooting, and ultimately on yield. Their hypotheses were thus:

(i) Yields may be limited by rooting depth, with cereal & oilseed crops unable to sufficiently root to below 1m to access sufficient water;
(ii) Deep burrowing earthworms can facilitate deeper rooting; and
(iii) Reduced soil cultivation and the addition of farmyard manure can thus increase earthworm populations, improve rooting depth and improve crop yields."

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Figure 1: Members of the Deeper Rooting FIG at a field site.

The Approach

The Deeper Rooting FIG involved four farmers who each set up different tramline trials on their farms to test the effects of cultivation treatments differing in level of soil disturbance. Cultivation treatments included deep cultivation, shallow cultivation, strip tillage, minimal tillage, flat lift and direct drilling and in some cases were in combination with addition of farmyard cattle manure (FYM).

Trial design differed between the farm locations as each farmer selected a set of treatments relevant to their current farming system. A total of six study fields was used.

In early spring (2019), the number of earthworms and middens were counted in line with AHDB guidelines. Middens are small deposits of straw/leaf litter and earthworm casts (soil and plant material which has passed through the earthworm cut) found at the burrow entrance therefore providing strong evidence for the presence of anecic earthworms.

Soil structure was assessed using visual evaluation of soil structure both in the topsoil (0-20cm: VESS) and sub-soil (c. 40-60cm: Sub-VESS) and soil strength (penetration resistance) was measured through the soil profile using a penetrologger.

The impact of the treatments upon normalized difference vegetation index (NDVI) of the crop, was monitored through the season using satellite images.

In June 2019, semi-quantitative measures of rooting depth were recorded by digging soil pits (*c.* 1 m depth) to visually assess rooting depth across the soil profile. At harvest crop yield data was collected from the trial areas using yield mapping combines. This was analysed using the ADAS agronomics methodology to test for treatment effects upon crop yield.

The Results

Spring earthworm counts showed a trend for greater numbers of earthworms with farmyard manure (FYM) application (Fig. 2) with an average of 6 earthworms per sample pit with FYM compared to 3 per pit without FYM addition. Similarly, a trend for higher midden counts with FYM application was shown (Fig. 3). There was also a trend for higher earthworm numbers with direct drilling compared to deep cultivation (Fig. 2). However, both midden counts and earthworm numbers were variable between the trial fields.

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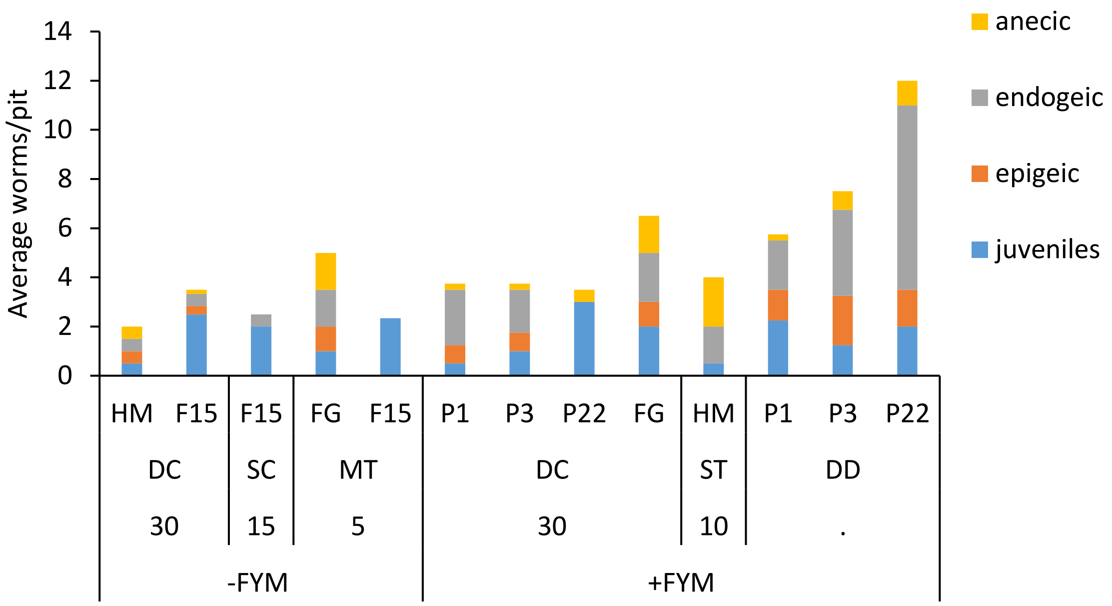

Fig. 2. Earthworm numbers by functional group. Treatments; DC = deep cultivation (30 cm); SC = shallow cultivation (15 cm), MT = minimum tillage (5 cm); ST = strip tillage (10 cm); DD = direct drilling; -FYM = no farmyard manure, +FYM = farmyard manure added. HM, F15, FG, P1, P3 and P22 refer to different study fields.

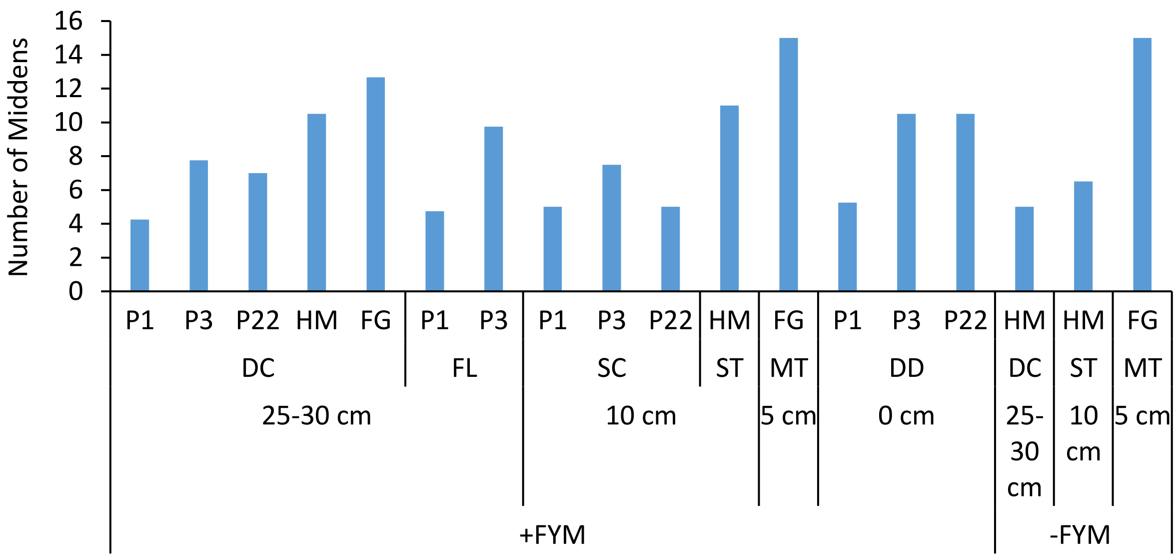

Fig 3. Midden counts. Treatments; DC = deep cultivation (30 cm); FL = Flat lift; SC = shallow cultivation (10 cm), ST = shallow till (10 cm); MT = minimal till (5 cm); DD = direct drill; -FYM = no farmyard manure, +FYM = farmyard manure added. P1, P3, P22, HM and FG refer to different study fields.

Visual examination of rooting depth showed that sufficient roots were present in all treatments at depths of around 90 cm. This was possibly due to favourable growth conditions in the autumn of 2018. Soil strength measurements showed no consistent effect of treatment.

Crop growth and yield data were only available from two of the farms. At one site the statistical model indicated that there was no significant difference in yields, with the shallow cultivation treatment (the farm standard) yielding on average 11.57 t/ha and the minimum tillage and deep cultivation treatments 0.44 t/ha ± 0.71 and 0.77 t/ha ± 0.84 less, respectively. At the other site the strip tillage with FYM addition (farm standard) yielded on average 9.70 t/ha and significant yield reductions were seen in all three trial treatments; deep cultivation with FYM addition -0.28 t/ha ± 0.20; strip tillage with no FYM – 0.49 t/ha ± 0.21; deep cultivation with no FYM – 0.70 t/ha ± 0.21.

Fig. 4. Yield map of one study site showing treatment effects on yield compared to strip tillage with FYM addition (farm standard). Treatments: deep cultivation with FYM addition (blue outline); strip tillage with no FYM (green outline); deep cultivation with no FYM (pink outline).

Discussion & Conclusions

The results of these trials show that FYM addition with reduced tillage was beneficial for yield at one of the sites although the reason for this beneficial effect could obviously have been due to nutrition rather than effects on rooting. The data also suggest that FYM and reduced cultivation were associated with improved earthworm numbers although these effects were variable between study fields.

The FIG has secured funding from Innovative Farmers to repeat the trials for a second year, so this FIG has now become a 'Field Lab' here. It is expected that larger effects of treatments will be found in the second year as this will allow more time for earthworm populations to recover.

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