IMPROVING CULTIVATION PRACTICES IN POTATOES

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Background

Potato seedbeds are generally cultivated deeper and more aggressively than many other arable crops. Over-working soil to excessive depth with destoning/declodding and bedtilling operations in potato (and other vegetable) production is leading to loss of structure, porosity and drainage within seedbeds.

When cultivation is attempted at water contents above the Plastic Limit (PL), soil is simply remoulded without any breakup or crumbling and can lead to compaction. In order to produce sufficient soil for a potato seedbed, at least 20 cm of soil is required and heavier soils can be above the PL at this depth, resulting in restricted rooting.

Spring cultivations such as ploughing or bedforming can bring large clods of wet, unweathered soil onto the surface and this can dry hard within a few hours, necessitating intensive bedtilling operations in an effort to reduce the clod size sufficiently for the destoner to work at an acceptable rate. Without cultivating soil, drying to the depths needed to produce adequate soil for destoning is very slow and growers are left in a quandary: progress with cultivation in the knowledge that soil damage will occur or wait until the soil is fit to cultivate. With better knowledge of the critical depths of cultivation on heavier soils, growers would be able to judge a more effective cultivation strategy.

AHDB Potatoes-sponsored Project R459 aimed to improve cultivation practices in potatoes, increase soil structural stability, and lengthen the window of cultivability by adjusting cultivation practices and increase nitrogen (N) use efficiency. Fifty replicated-block experiments, mostly in commercial potato fields, were conducted on varying soil types over the period 2011-2014.

Key findings

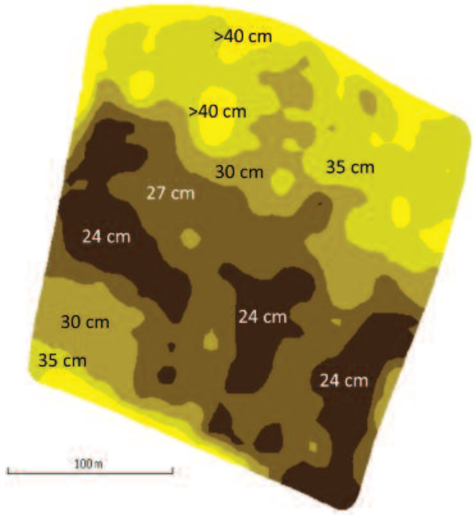
Destoning 5-9 cm shallower than the standard depth used by growers on sandy soils (30-38 cm) resulted in no yield loss or even a slight yield increase (c. 1 t/ha). The optimum destoning depth in such soils was close to 27 or 28 cm, with no issues relating to planting depth, emergence, tuber quality and, on the majority of sites, no reduction in harvestability or increases in bruising.

On heavier soils (e.g. clay loams and clays), destoning 3-5 cm shallower than commercial practice (28 cm) resulted in a yield increase of c. 1.8 t/ha. The decrease in yield observed when destoning deeper than standard current practice should be a serious concern for growers as the yield losses in heavier soils as a consequence of compaction and impeded drainage were sometimes very large (> 10 t/ha).

The critical cultivation depth in most springs would be shallow enough to cause issues of compaction, even by cultivating at the standard depths used by the industry. Growers should also be aware, that owing to alterations in previous cropping, trafficking and cultivation regimes and rainfall patterns, the critical cultivation depth can vary between seasons by 3-5 cm, even in the same field.

Using data from electrical conductance (EC) scans combined with soil texture, organic matter and Equation 13 in Keller & Dexter (2012) to calculate the PL variation across a field, a zonal map of critical destoning depth could be constructed which highlights critical areas in the field and would make cultivation more effective, irrespective of the crop (Figure 1). Having such maps would guide growers and

Figure 1. Map of critical cultivation depth in The Cliff field superimposed on the EC map. Depths relate to the depth of destoned bed capable of being produced without plastic compaction. Data derived from two experiments in 2014



operators over the optimum destoning depth and allow them to adjust machinery depth on the move if the tractor had access to GPS location data. This approach of variable cultivation depth related to soil type could lead to significant improvements in yield which could pay for the technology required to implement, especially since EC maps, once created, give guidance on likely soil boundaries for all subsequent cultivations.

Taking a representative sandy clay loam soil at NIAB CUF, calculations were made to estimate the number of days in spring when soil could be cultivated at different depths without causing plastic damage to the soil while ploughing or rotary cultivating. In the driest seasons (e.g. 2011), 75 days would be available to plough to 30 cm depth out of a possible 91 days but in the wettest seasons (e.g. 1994, 2000 or 2001), less than 15 days would be available for cultivating without the risk of shearing compaction (plastic deformation) of wet soil.

The average, based on 1991-2014, shows that only around 34 days would be available to plant if cultivating took place at 30 cm. By reducing the cultivation depth, this window would increase to 40 days at 27 cm and 45 days at 23 cm. The latter depth would be sufficient, except on very stony soils, to produce destoned beds 28 cm deep prior to planting. Additionally, altering destoning depth did not change the quantity of available soil nitrogen or nitrogen uptake and therefore shallower cultivation would not alter any fertiliser recommendation.

Growers frequently strive for an unnecessarily deep seedbed on heavier soils. In doing so they lift overly-wet soil with the destoner share onto separating stars or webs. This largely gets transported into the adjacent furrow to be compressed by the next pass of destoning (Figure 2), where it cannot be utilised by crop roots and causes difficulties at harvesting.

On heavier-textured soils, a good correlation was observed between the critical depth for destoning as measured by the PL and the quantity of soil being deposited in the furrow having failed to be worked into aggregates of suitable size. As a simple practical recommendation, if a destoner operator was to gradually increase the depth of working, they would be able to observe the sudden change in soil being placed in the furrow and this would indicate that they were close to the critical depth for cultivation.

Over-working soils by destoning at depths >30 cm sometimes resulted in looser soil within the ridge than shallow destoning, but by harvest this extra porosity had frequently been lost and soils were more dense that where destoning was carried out at shallower depths. There were small benefits in reduced soil resistance and lower bulk density resulting from destoning more deeply, however these did not translate into improvements in yield or quality.

The higher clay content soils had lower ridge bulk densities than sandier soils, and

Figure 2. Destoner operation excessively deep in wet soil showing clod being transported to wheelings

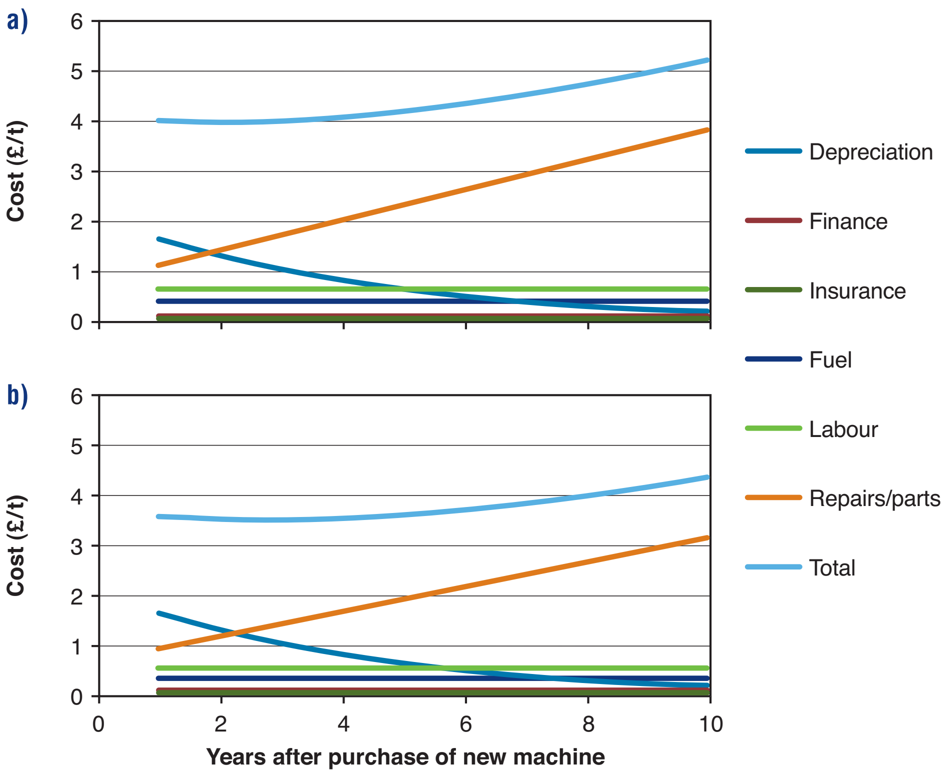
generally the greater the clay content, the greater the increase in density during the season, with up to 35% increase in density in the highest clay content soil. The sandiest sites, while having high ridge densities at planting, often exhibited smaller changes in ridge density during the season.

It should be emphasised, however, that the ridge densities of clay soils at planting were very low and did not increase to the density of sandy soils despite slumping: they remained porous and loose right through until harvest. The clay soils had the highest OM content (3-4%), which would have contributed to aggregate formation and stability.

Perhaps contrary to perceived views, very shallow destoning on heavy soils (>20% clay content) often resulted in ridges composed of smaller soil particles (peds) with fewer very large (>35 mm diameter) peds than ridges created from soil destoned deeper than c. 35 cm. Mean ped size increased from planting to harvest in heavy soils as fine particles of soil (increased by aggressive, deep destoning) re-aggregated during the season. Additionally, working soils close to, or above, their PL resulted in the formation of clods of the size which were left in the ridge rather than being deposited in the wheeled furrows.

An overall improvement in rate of work of c. 40% was achieved by destoning 9 cm shallower than the commercial depth (average 33 cm), which speeds up what is often the rate-determining step in the planting operation. At a depth more suitable for commercial production and safe harvesting (27-28 cm), the rate of work was still 19% faster than the current commercial rate. Large potato businesses working at full capacity often have little safety built in for delays caused by

Figure 3. Calculated costs for destoning at a) 34 cm; b) 28 cm depth for a single Grimme CS150 on 120 ha of stony sandy loam soil



KELLER, T. & DEXTER, A.R. (2012). Plastic limits of agricultural soils as functions of soil texture and organic matter content. *Soil Research* **50**, 7-17

inclement weather. There were also significant savings in fuel (£6-11/ha) from cultivating beds shallower than current commercial depths, but the cost saving per tonne of harvested tubers was small (c. £0.10-0.20/tonne).

Potato planting involves the use of highly specialised and often expensive machinery. Averaged over ten years following the purchase of a new Star destoner, for standard commercial depth destoning, the cost of destoner repairs and parts were calculated at c. £2.49/t (£142/ha) based on a yield of 53.2 t/ha, out of a total cost for depreciation, fuel, labour, finance and insurance of £4.41/t (£248/ha). Reducing the depth of destoning to 28 cm (associated with a yield increase to 55 t/ha) reduced the total cost to £3.77/t (£213/ha), of which repairs and parts contributed £2.05/t (£117/ha). Reduced fuel, labour and repairs and parts with shallower destoning contributed £0.07, 0.11 and 0.44/t cost savings, respectively, compared with standard-depth destoning (Figure 3).

Destoning shallower would allow cultivation to be timed better with respect to soil conditions. This project suggests this could be worth c. 1.8 t/ha and this has been taken into account in this cost study. However, in wet springs when planting can be delayed well into May or even June, thereby incurring a yield loss owing to a truncated growing period, the ability to travel 20% faster with shallower destoning could have a much larger effect on yield.

The article has been reproduced from NIAB TAG's membership magazine *Landmark* (March 2016 edition).