On the go measurements of penetration resistance and yield and the effect of deep loosening

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Abstract. A horizontal, on-line penetrometer has been used on several fields in Sweden to measure penetration resistance. The yield on these fields have been mapped and compared to the penetration resistance. In some of the fields, deep loosening has been done on parts of the field in order to be able to study the effects on the yield. Some correlation of higher penetration resistance and lower yield has been found but no positive effect of the deep loosening was discovered.

Keywords: GIS, site-specific measurements, penetration resistance, yield

1 Introduction

Yield variations within fields can be very high, several tons of grain per hectare (Thylén, 1997). If the reasons for these variations are known, site-specific inputs can save resources, the negative effects on the environment can be reduced and yield levels can be maintained or even increased (Robert, 1999). Relationships between soil physical parameters and yield, especially in the subsoil, are seldom studied, often due to labour intensive, and therefor expensive, methods of measuring such parameters. The spatial variation in cone index and other physical parameters has been studied by a number of researchers but few have studied the relationship with yield (Isaac et al, 2002; To & Kay, 2005). A large Swedish study on yield variations in sugar beet showed that factors influencing root development and water transport in soil had the largest effect on yield (Berglund et al, 2002).

The objective of the present study was to use a site-specific horizontal, on-line, soil penetrometer for studying soil penetration resistance and its correlation with yield. The effects of deep loosening on yield was also studied.

2 Equipment

A four-share parallel-plough was modified to support three parallel, horizontally mounted, soil penetrating cones, (see figure 1 and 2). The cone-angle was 30°, with a base diameter of 6.3 cm. The cone was connected to a Bosch draught sensor capable of registering forces between –25 kN and +25 kN. The instrument is capable of measuring soil penetration resistance at three depths (10, 30 and 50 cm), speed and position which are recorded with a Trimble SweeEight GPS every second. The

In: M. Salampasis, A. Matopoulos (eds.): Proceedings of the International Conference on Information and Communication Technologies

for Sustainable Agri-production and Environment (HAICTA 2011), Skiathos, 8-11 September, 2011.

instrument was used at a speed of approximately 1.5 m s^{-1} and was equipped with a stone release mechanism and a system to record actual working depth every second. The 1000 Hz signal from the draught sensor was reduced to a 1 Hz signal to lessen the noise.

Fig 1. Soil penetrating cone and draught sensor.

Fig 2. One of the three soil penetrating cones.

3 Results

Fig. 3 shows a yield map for a field while Fig. 4 shows data from penetration resistance measurements at 30 cm depth performed after harvest. There was an inverse correlation between penetration resistance and yield (Figs. 3 and 4) with higher yields obtained at areas of lower resistance. The left part of the maps show both a higher yield (fig. 3) and lower penetration resistance (fig 4) and the opposite is true for the right part of the map.

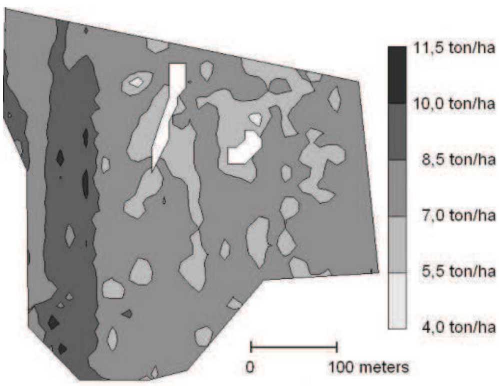

Fig. 3. Yield of spring barley (ton ha^{-1}).

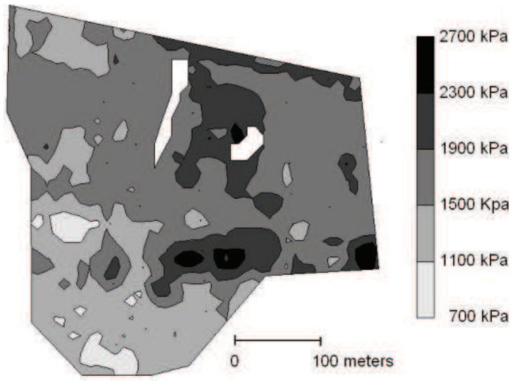

Fig. 4. Penetration resistance (kPa) at 30 cm depth.

Figure 5 shows a field where parts of the field was deep loosened. Some differences could be seen in penetration resistance between loosened and unloosened parts of the field (fig 6) but these differences was however not visible on the yield map.

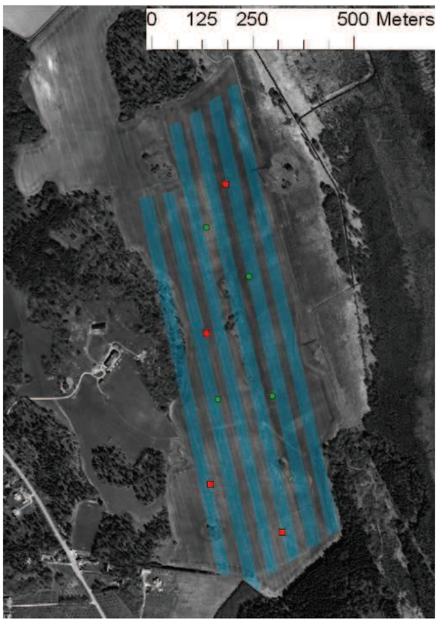

Fig. 5. The strips show the area that was deep loosened. The red and green dots show places that were more intensely sampled.

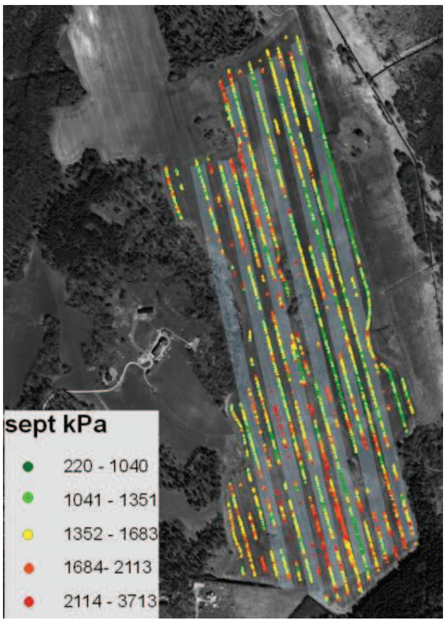

Fig. 6. Penetration resistance at 30 cm. Measurements done in September.

3 Conclusions

The horizontal penetrometer worked well in the field. The signals were stable and the construction was sufficiently robust to tolerate stones in the soil. The measurements show that variations in penetration resistance can explain part of the variation in crop yield. This horizontal, on-line penetrometer can measure a large area considerably faster than a traditional penetrometer, which will make it easier to incorporate soil physical parameters into precision agriculture.

References

1. Isaac, N.E., Taylor, R.K., Staggenborg, S.A., Schrock, M.D. and Leikam, D.F., (2002) Using cone index data to explain yield variation within field. Agricultural engineering. 4, 19-33.
2. Robert, P. (1999) Precision Agriculture: research needs and status in the USA. In: Precision Agriculture ´99, J.V. Stafford (Ed), UK, BIOS Scientific Publishers, pp. 19-33.
3. Thylén, L., (1997). Consistency in yield variation and optimal nitrogen rate. In: Stafford J.V. (Ed), Precision Agriculture ´97, UK, BIOS Scientific Publishers, pp. 345-350
4. To, J. and Kay B.D., (2005). Variation in penetrometer resistance with soil properties: The contribution of effective stress and implications for pedotransfer functions. Geoderma 126, 261-276