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Effect of site-based precision fertilisation on yield and oil content of spring oilseed rape seeds

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Abstract. The experiments using two fertilisation methods on the spring oilseed rape in 2012 were carried out in two places – on the Eerika experimental field of the Estonian University of Life Sciences and on the Erumäe producing field of the Pilsu farm. The aim of this work was to investigate site-based precision fertilisation on the spring oilseed rape yield and oil content in oilseed rape seeds. The preceding crop was spring wheat in both fields. Five treatments were used: control treatment (without fertilisers, C), common fertilising system (CvS), fertilisation by site-specific information (SI), fertilisation by site-specific information additionally with mineral nitrogen fertiliser (SI+MF), and site-specific fertilisation additionally with foliar nitrogen fertiliser (SI+FF). The highest seed and oil yield was achieved in treatments fertilised by site-specific information additionally with foliage nitrogen fertiliser. In the production field, the statistically significant seed and oil yield increase was achieved in treatment. Oil content of spring oilseed rape seeds was higher in treatments C and CvS. In both trials, additional fertilising with foliar nitrogen (including microelements, SI+FF) increased the oil content of oilseed rape seeds. There was a negative correlation between the oil content and seed yield of spring oilseed rape.

Key words: spring oilseed rape, soil nutrient content, precision fertilising, foliar fertilising.

INTRODUCTION

Current applied methods in agriculture use precisely controlled movement of the machinery in the field conducted by exploitation of Global Positioning System (GPS). GPS navigation system gives operatively necessary information of the position of the agricultural machinery and the movement in the field (Ludowicy et al., 2002; Robinson 2007; Nugis et al., 2010; Võsa et al., 2009). While the ultimate goal in the field is crop yield, it is important to notice the yield potential of different parts in the specific field. Primary information for this purpose is obtained from the yield map.

In addition to locating the position of the machinery, information on soil properties is also important. Thus the Geo Information System (GIS) database has become an inseparable part of precision farming (Jordan et al., 2005; Santhi et al., 2005). Collection of soil samples is the first step in monitoring soil nutrients and the creating of site-specific database (Crozier et al., 1998).

Variation details of soil nutrients content, acidity, etc. within the field are received by GIS applications. The use of IT applications and digitised yield maps based on soil properties is an advantageous tool when used with GPS navigation system devices. Work process parameters can be operatively changed according to the need while the machinery moves on the field.

Real need for additional fertilisation of the fields can be assessed not only by soil properties data but also by the analysis of plant data. Excess fertilisers on the field are an additional economic cost for the farmer and can also increase the environmental load from leached nutrients. Experiments have shown that the nutrient flow through the plant leaves during the peak demand period helps the plant get over the critical moment quickly, improves absorption of the nitrogen in the metabolic processes and prevents loss of yield and quality. Furthermore, it also improves efficiency in the use of other nutrients and reduces the risk of nitrogen leaching (Järvan, 2006).

It is necessary in site-based fertilisation to understand the basis of both, soil and plant info. The aim of this study was to investigate the effect of site-specific precision fertilising on spring oilseed rape seed yield and oil content.

MATERIAL AND METHODS

The spring oilseed rape seed experiments with precision fertilising were conducted in spring 2012. The fields used in experiments were the experimental field of the Estonian University of Life Sciences in Eerika, and the producing field experiment was established in the Erumäe Pilsu farm. Both fields are located in Tartu County. Previous crop was spring wheat.

Soil samples for chemical analyses were taken from the fields in autumn 2011. Chemical analyses were made in the Agricultural Research Centre (PMK) laboratory where the levels of soil pH, organic carbon (Corg), nitrogen (N%), phosphorus (P) and potassium (K) were determined per mg 100 g^{-1} of soil.

The fertilising of the fields with mineral nitrogen fertiliser from site-specific information according to the experimental scheme took place in spring 2012. Because the soil phosphorus (P) content was predominantly low in Erumäe production field the additional fertilising was carried out with phosphorus mineral fertiliser MAP 12-52 Soltex (N-12; P_2O_5-52) before the experiment. For fertilising work fertiliser spreader Amazone ZG-B 8200 was used with a work width of 24 metres. In site-specific treatments the fertilisation need was determined by soil parameters information and additional fertilisation was regulated by the GPS navigation system automatically on the movement of the machinery. Data use originated from the digitalised fertilising maps data set (Fig. 1 A). AgLeader SMS software used allows visualising and analysing of data and compiling of work plans for machinery. Work map MAP for fertilisation was compiled with AgLeader SMS software (Fig. 1. A). An AgLeader precision fertilising monitor was used for monitoring the fertilisation process and to view the map in the tractor cabin in real time.

Potassium content was low in the Eerika experimental field soil. Potassium rich fertiliser Yara Cropcare PK (3-11-24) was added manually to this field correspondingly to the sites soil analysis results. Necessary norms of NPK: N – 59 kg; P – 11 kg; K – 39 kg for 1 tons of oilseed rape seeds yield were taken into account while calculating fertilising norms for fields in the present experiment. Estimated oilseed rape seed yield was 2.5 t ha^{-1} for Eerika experimental field and 3.0 t ha^{-1} for Erumäe production field.

Nitrogen mineral fertiliser of ammonium nitrate (N 34.4%) was spread separately followed by spring oilseed rape sowing.

In Eerika experimental field spring oilseed rape variety 'Fenja' and in Erumäe production field variety 'Campino' was sowed in spring 2012. Väderstad Pneumo seeder with a work width of 8 metres was used for sowing.

Nutricomplex 14-11-25 (containing MgO, SO_3, Mn, B, Cu, Zn, Fe) with the norm up to 4 kg ha^{-1} was used in treatment SI+FF during the growth period.

The need for additional fertilisation during the growth period was obtained from chlorophyll measurements made with Minolta SPAD chlorophyll measurer in Erica experimental field. For the same purpose AgLeader equipment OptRx with N sensor chlorophyll measurer was used in Erumäe production field. Agricultural sprayer was used for foliar fertilising. Crop was harvested with agricultural harvester New Holland CX860 equipped with devices for mapping yield (Fig. 1 B) and position in the field. Yield map was obtained as a result of harvesting with this equipment.

To determine the content of raw oil (%), and also protein (%), glucosinolates (μmol g^{-1}), chlorophyll (ppm in oil), eruca acid (%) and free fat acid (%) samples from oilseed rape seed yield were collected during harvesting and sent to the Agricultural Research Centre laboratory for analysis.

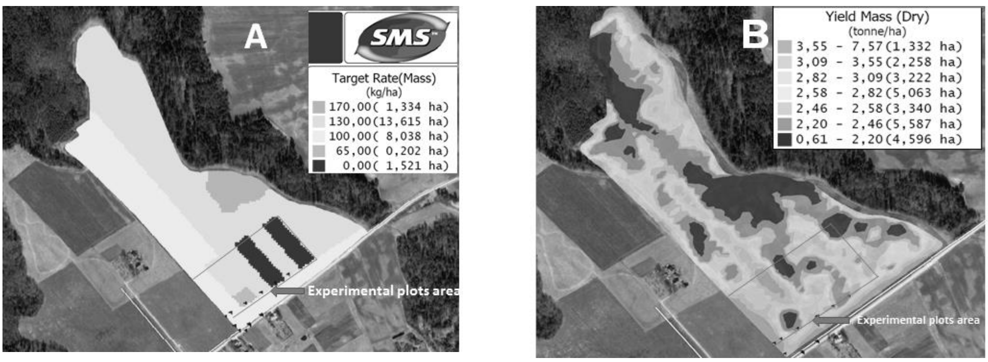

Figure 1. Fertilising map for Erumäe production field (A) and oilseed rape seeds yield map (B).

Experimental treatments:

1. Control treatment (C) – without fertilisers;

2. Conventional fertilising system (CvF) – mineral NPK fertiliser added according to conventional agricultural practice;

3. Fertilisation by site-specific information I (according to soil properties, SI) – mineral NPK fertiliser added during sowing according to the soil nutrients deficiency;

4. Fertilisation by site-specific information II (SI+MF) – mineral NPK fertiliser added during sowing according to the soil nutrients deficiency + mineral N added during growth and need estimated by chlorophyll measurer;

5. Fertilisation by site-specific information III (SI+FF) – mineral NPK fertiliser added during sowing according to the soil nutrients deficiency + foliage nitrogen fertiliser during growth period added according to the N deficiency.

RESULTS AND DISCUSSION

Rape seeds yield

The highest spring oilseed rape seed yield was achieved in both, in the experimental field and in the production field under treatments SI+FF (Fig. 2 A and B). Seed yield in the last mentioned treatment was 6.6% higher compared to CvF treatments in Eerika experimental field. The disparity between treatments was even higher in Erumäe production field – 21.6%.

A high spring oilseed rape seed yield increase by 9.4%, compared to CvF treatments, was achieved in Erumäe production field in treatments SI+MF. Thus, both treatments of fertilising during the growth period in 2012 in the production field experiment gave positive results in spring oilseed rape growth. Although, in the experimental field of Eerika the yield with SI and SI+MF treatments compared to control treatment was higher by 3.3% and 5.6% accordingly, they were not statistically significant.

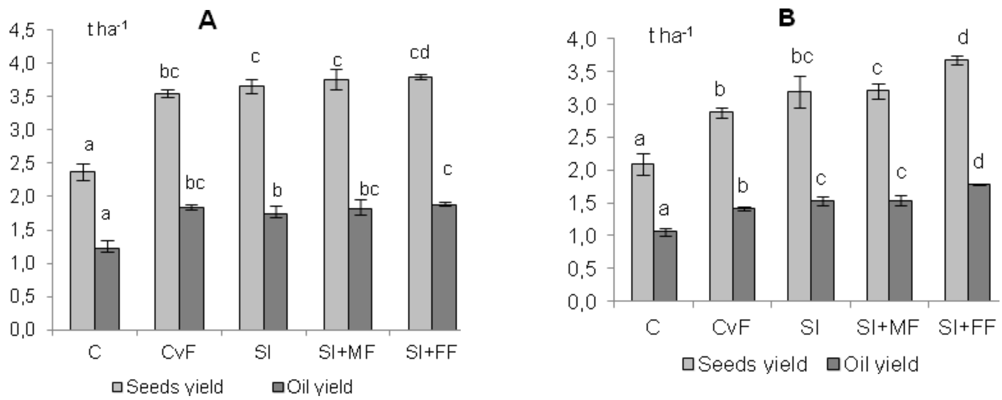

Figure 2. The seeds and raw oil yield (t ha^{-1}) of spring oilseed rape in experimental field of Eerika (A) and in production field of Erumäe (B), I – SE, *n* = 4.

Raw oil yield

In the production field experiment of Erumäe the same treatments as yield of seeds gave the highest yield of raw oil (var. SI, SI+MF and SI+FF, Fig. 2 B), 1.5, 1.5 and 1.8 t ha^{-1} accordingly. But in the experimental field experiment of Eerika the oil yield was more or less similar in all treatments, except the control treatment. Furthermore, in treatment with SI+FF the yield was one of the highest. The difference between control and SI treatment was 6.9% (Fig. 2 A). The oil yield depends on seeds yield of spring oilseed rape and oil content of the seeds.

Raw oil content

Both, in the experimental field of Eerika and in the production field of Erumäe the oil content of seeds were highest in treatments C and CvF (Fig. 3 A).

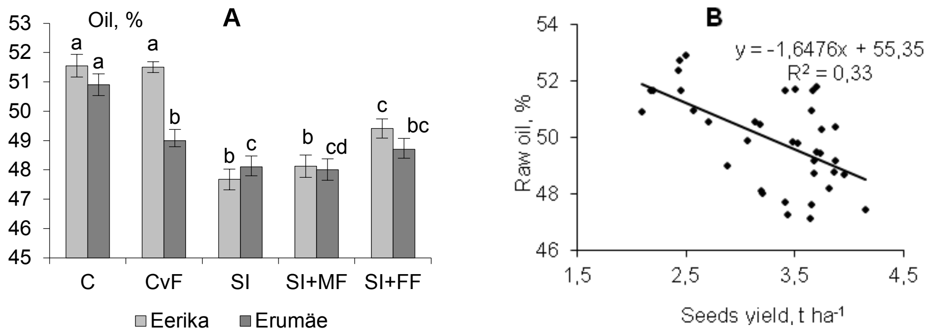

Figure 3. Spring oilseed rape oil content of seeds in Eerika and in Erumäe experiments (A), I – SE, $n = 4$ and correlation between oil content and yield of seeds in averages in experimental field and in production field experiments (B), $n = 38$.

Both, in Eerika and in Erumäe the oil content of seeds from other treatments was higher in treatments SI+FF seeds, being 1.3–1.7% higher in Eerika and 0.5% higher in Erumäe than in treatments SI and SI+MF. According to Lääniste et al. (2004) adding microelements increases the oil contents of spring oilseed rape seeds. Foliar fertiliser (Nutricomplex) used in the experiment contained sulphur (S) and magnesium (Mg).

Oil content of spring oilseed rape seeds was in negative correlation with seed yields (R = 0.57** Fig. 3 B). That means that with a higher yield of seeds the oil content of seeds is less. Many experiments show that this can be explained by increased access to nitrogen fertiliser. Rathke et al. (2005) and Ahmad et al. (2007) show negative correlation between raw oil content and access to nitrogen fertiliser. But according to Järvan (2011) the sulphur containing nitrogen fertilisers increase the yield and oil content of oilseed rape seeds and thus increase the profit by getting higher rape oil production. This was observed in the current study as well. The treatment SI+FF (the used fertiliser Nutricomplex contains microelements and sulphur) showed the tendency of increased yield of seeds, higher oil content and higher production of raw oil as compared to treatments SI and SI+MF.

CONCLUSIONS

The study is based on the Eerika experimental field data of the Estonian University of Life Sciences and on the Erumäe Pilsu farm's production field data.

The preceding crop was spring wheat. Five treatments were used: control treatment (without fertilisers, C), common fertilising system (CvF), fertilisation by site-specific information (SI), fertilisation by site-specific information additionally with mineral nitrogen fertiliser (SI+MF), and site-specific fertilisation additionally with foliar nitrogen fertiliser (SI+FF). In the two last treatments the need for fertilisation was obtained from chlorophyll measurements.

The highest seed and oil yield was achieved in treatments fertilised by site-specific information additionally with foliar nitrogen fertiliser (SI+FF).

In comparison with common treatments (CvF) and fertilisation by site-specific information and additionally with mineral nitrogen fertiliser (SI+MF) on Erumäe production field experiment, the acceptable seed and oil yield increase was achieved on sites treated with additional mineral nitrogen fertiliser (SI, SI+MF and SI+FF).

Oil content in spring oilseed rape seeds was higher in control and in common treatments. In both trials, additional foliar fertilising (including microelements, e.g. sulphur) increased the oil content in spring oilseed rape seeds. There was a negative correlation between the oil content and seed yield in spring oilseed rape.

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