

Preliminary study on fuel usage in fruit productions in Poland.

Paweł Białkowski, Paweł Wawrzyńczak, Paweł Konopacki, Jacek Rabcewicz

Research Institute of Horticulture, Agroengineering Department, Skierniewice, Poland

Fruit production is one of the most important branches of agriculture in Poland. It is estimated that fruit trees are grown on the surface of 278 thousand hectares with yield about 3 million tons per year of which apples produce 2500 thousand tons, sour cherries produce 175 thousand tons, and plums produce 99 thousand tons. The conducted research on diesel oil consumption on fruit farms showed that the annual fuel consumption ranges from 118 to 125 litres per hectare. During the growing season, more than 80% of fuels is consumed in the second and third quarter of the year. The main agronomic treatments requiring large energy input are plant protection (25 to 30 treatments per season) and soil care (especially preservation of grass alleys between rows which requires 4 to 8 treatments per season). These two types of treatments represent 65% of energy consumption. Direct measurements and observations conducted in our project indicate that these treatments should be the subjects of energy savings.



Photo 1. Sprayer with axial fan



Photo 2. Sprayer with radial fan



Photo 3. Rotary mower



Photo 4. Flail mower

The number of protection treatments may be reduced by carrying out some treatments together. However, one has to be sure that the mixing of plant protection products (PPP) is acceptable (mixing charts). The average time of the treatment per one hectare depends on the distance between rows, and amounts 20 min for 5.0 m row spacing, 30 min for 4.0 m row spacing, and 35 min for 3.5 m row spacing. The sprayer should have adequate air flow – from at least 8000 m³*h⁻¹ for the raspberries, up to over 40000 m³*h⁻¹ for orchards with 5 m tree row spacing (Tab 1). The important work parameters are: the working speed should not exceed 2 m*s⁻¹, and the pressure has to be between 5 and 15 bars (optimally 8-12 bars). Measurements of the power demand has revealed that under average conditions of fruit production 21-31 kW are required for axial fan sprayer, and 30-40 kW for radial fan sprayer (Tab. 1).

Table 1. Some parameters of orchard sprayers.

Lp.	Sprayer	Type of fan	Fan efficiency (m ³ *h ⁻¹)	Power demand (kW)	Minimum tractor power (kW)
1	Śleza 1014	Axial	36000	22	35
2	Śleza Milenium 1500	Axial	39000	31	43
3	Agrola 1500	Axial	30000	21	35
4	Agrola 1000 eko	Axial	40000	21	35
5	Hardi TS 1082	Axial	45000	22	35
6	Vento 1500	Radial	11000	40	57
7	KWH Holland	Radial	11500	30	43

Reduced fuel consumption may be also expected when the tractor coupled with the machine operates under a load of about 70% of the nominal power of the engine. At this point the engines have the lowest specific fuel consumption. Some mowers have technical possibility of connecting the sprayer, so the two treatments may be carried out simultaneously. In this situation, one have to be sure that the engine power of the used tractor enables to cope with the power demand of the two treatments, but total fuel consumption should be much lower (around 20-30% less) than for the execution of these operations separately. Similarly, tractors with a front suspension system are also capable to perform two treatments at same time (plant protection and grass mowing).

Table 2. Power consumption of different types of mowers.

Lp.	Mowers	Width (m)	Number of working sections	Power demand (kW*m ⁻¹)	Minimum tractor power (kW)
1	Rotary	2.4	2	7.5	26
2	Rotary	2.2	2	6.5	20
3	Rotary	2.0	2	6	18
4	Rotary	2.0	1	11	30
5	Flail	1.5	1	12	25

In the case of grass mowing the major energy savings may be obtained by selection of a suitable type of grass mower, i.e. flail mower or rotary mower. Measurements and observations of soil care treatments show that the average consumption of fuel per one hectare of orchard for a single treatment ranges from 1.35 to 2.20 l*ha⁻¹, with the average 1.51 l*ha⁻¹. Measurements of the power demand have revealed that under average conditions of fruit production the power of 8-16 kW is required for rotary mowers, and power of 14-20 kW for flail mowers (Tab. 2). Power demand depends also on the design of the mower, which should be appropriate for work in the orchard. The working width of the mower should be adequate to the width of the grass between rows of trees. Recent studies show that optimization of these procedures can give fuel savings of 5-10%.