POWER SUPPLY OF TRACTORS ON AGRICULTURAL FARMS

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Abstract. The article shows changes in the structure of the tractor fleet and presents an analysis of the impact of the specific power supply (related to the power of the tractor engine) on such factors as the area under crop of the agricultural farm and the volume of output of the farms in Latvia which are engaged in the production of grain. The obtained model, the multiple regression equation, which describes well the dependency of specific power supply on the impact of the factors mentioned above. The given model allows prognosticating specific power supply depending on the variations in the magnitude of these factors. The model allows also to obtain a qualitative estimation of the impact of each discussed factor separately on specific power supply.

Key words: model, multiple regression, specific power supply, power of the tractor.

Introduction

Important factors for the development of the agricultural branch are: the level of mechanisation, application of up-to-date technical means and technologies which ensure the output of competitive products. Besides, when choice is made of technical means, each farm should have a motivated estimation of an expedient level of power supply considering the increase in production, economy of resources and minimising the adverse impact on the natural environment.

The analysis of data shows an obvious trend towards the enlargement of the development of agricultural farms in Latvia. So in the year 2004, in contrast to 2000, the number of farms engaged in the production of grain and having more than 50 ha of the areas under crop increased by 1.7%, but their areas under crop grew by 28.8%. By the power of tractors per unit of the area under crop, the specific power supply on the farms having less than 50 ha is 7.87 kW/ha, but on the farms having more than 50 ha is 2.78 kW/ha, or 2.8 times less [1]. In many respects such a situation can be explained by a more efficient use of tractors on large farms. On the basis of the correlation of the level of specific power supply and the per-hectare consumption of fuel it is possible to estimate the impact of the technical supply of agricultural production on the natural environment and economy of energy resources [2].

Materials and methods

The purpose of this paper is to determine the impact of the size of the area under crop of a farm and the volume of the output on the farms (production of grain) upon the level of specific power supply.

In order to determine the interdependency of the above-mentioned factors and specific power supply, the regression analysis is used [3]. The development of the multiple regression model allows prognosticating the values of specific power supply by the values of the discussed factors.

The object of this investigation are the farms engaged in grain production, their total areas under crop, the volume of output, power supply by the engine power of tractors. The data provided by the Latvian State Central Board of Statistics and the State Agency of Technical Supervision are used in this work.

Results and discussion

Technical and economic indices of tractors are determined by the producers of agricultural products. The highest priority in choosing tractors in the period from the year 2000 to the year 2005 was given to 5 brands. The dynamics of their purchase is presented in Figure 1.

It is evident from Figure 1, that within the discussed group of tractors (MTZ, Valmet (Valtra), John Deere, Case, Fend) MTZ has the greatest specific weight. (The number of the purchased tractors MTZ is several times bigger than that of the other brands of tractors; therefore another scale for the MTZ tractors is accepted). However the number of the purchased MTZ tractors decreases with every year in relation to all the other brands of tractors acquired during the respective years. Thus in 2000 their ratio was 72% but in 2005 it was already 50%. The data indicate that, starting from the year

2001, increasing preference is given to the following brands of acquired tractors: Valmet (Valtra), John Deere, Case. It shows that in the renewal process of tractors the decisive factors are not only their prices but also reliability, energy intensity, possibilities of their efficient use, comfort, and other indices.

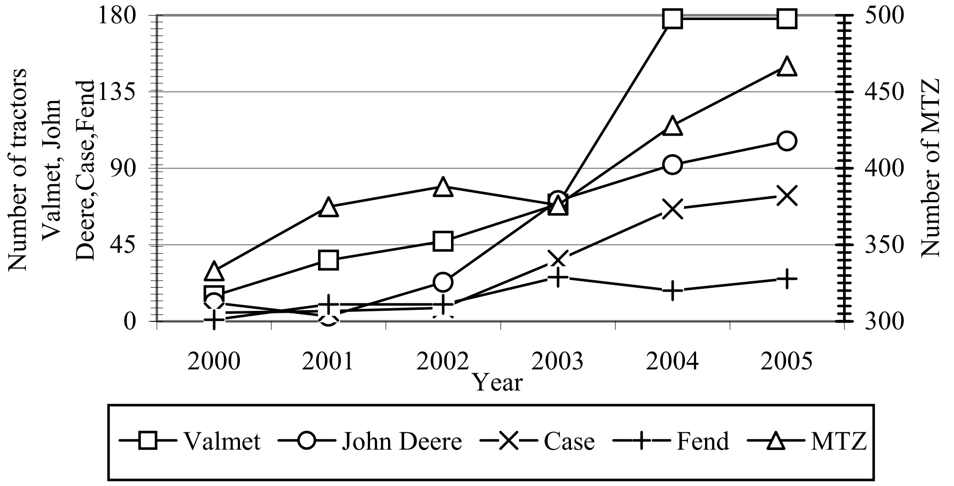

Fig. 1. **Dynamics of the purchase of priority tractors**

The analysis of data reveals that on the farms having more than 50 ha of the total areas under crop the average power of the tractor is 65 kW but on the farms with less than 50 ha it is 46 kW. Figure 2 shows the average power of the tractor and the power supply of farms with variable values of the total areas under crop.

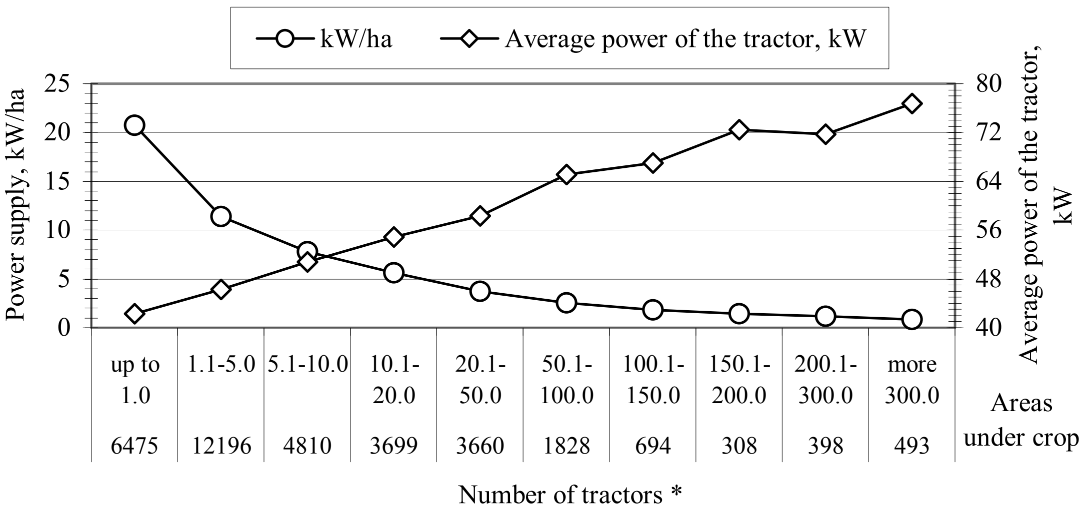

Fig. 2. **Dependence of the average power of the tractor and the specific power supply on the value of the total area under crop of the farm**: **Number of tractors – the number of tractors on the farms relating to the respective range of areas under crop*

It is evident from Figure 2, that the average power increases with the increase in the total area under crop but the specific power supply decreases. This indicates that energy intensive tractors are generally used on large farms. The high specific power supply on the farms with small total areas under crop can be explained by the great number of small-power tractors they have.

In order to clarify the degree and character of the impact of the size of the areas under crop of a farm, ha (X_1), and the volume of the output, t (X_2) upon the specific power supply (Y) on the farms of Latvia, their production structure being equal (the farms engaged in grain production), we determine a dependency model (Y) of the factors (X_1 and X_2) mentioned above. Since two independent variables X_1

and X_2 are included into the determined model of specific power supply, let us discuss the model of multiple regression. To determine its type, we examine the dependency between the dependent variable – *Y* and the independent variables (X_1 and X_2), we draw charts (Figure 1).

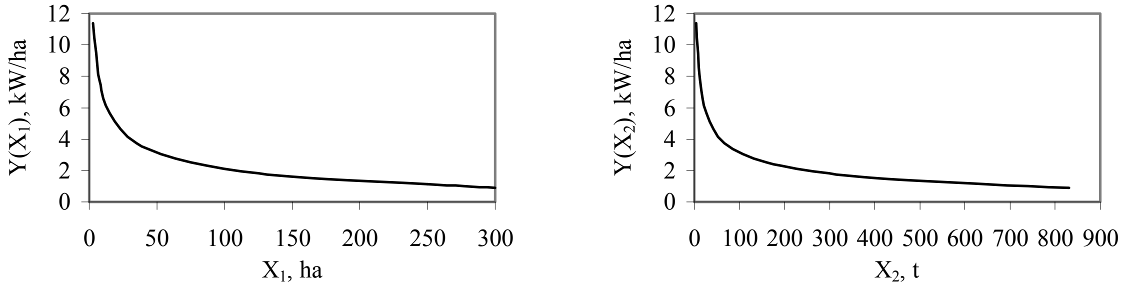

Fig. 3. **Dependency of *Y* on the given factors (X_1) and (X_2)**

It is obvious from Figure 3 that the independent variable (*Y*) has a non-linear character depending on each of the independent variables.

We treat the model of multiple regression in the following way:

$$Y = b_0 + b_1 \frac{1}{X_1} + b_2 \frac{1}{X_2},$$

where X_1 and X_2 – the independent variables;
b_0, b_1, b_2 – the coefficients of the multiple regression.

By designing $U_1 = \frac{1}{X_1}$ and $U_2 = \frac{1}{X_2}$,

we present the model of multiple regression in the following way:

$$Y = b_0 + b_1 U_1 + b_2 U_2 .$$

By means of the programme *MS Excel* we calculate the values of the coefficients of multiple regression.

The obtained values of the coefficients: $b_0 = 0.35$; $b_1 = 457.94$; $b_2 = -660.37$.

Consequently the concrete equation of the multiple regression model assumes the appearance:

$$Y = 0.35 + 457.94 U_1 - 660.37 U_2,$$

or passing over to the initial variables:

$$Y = 0.35 + 457.94 X_1^{-1} - 660.37 X_2^{-1} .$$

Besides, the determination coefficient R^2 shows that 99.7% of the specific power supply (*Y*) is described by means of the obtained model of multiple regression and it depends on the value of the area under crop (X_1) and the volume of the output (X_2) on the examined farms of the given structure.

Calculations indicate that with very great probability (practically 100%) the obtained regression model is statically significant.

When $F_{empirical} = 717.26$ (test statistics) and $F_{\alpha, critical} = 5.79$ $F_{\alpha, critical} < F_{empirical}$. The model is significant at the significance level $\alpha = 0.05$, i.e. the reliability of the static conclusion is equal to 0.95.

In the regression model under review variables X_1 and X_2 should be positive (X_1, $X_2 > 0$).

In the model presented above the lower limits of the factors under review have the following values: X_1 Ó 3 ha; X_2 Ó 4.7 t.

Table 1 presents the actual value of the specific power supply on the farms having equal areas under crop and volume of output, and its calculated value determined according to the above regression model.

Table 1

The actual and the calculated values of specific power supply

X_1	3.0	7.5	15.0	35.0	75.0	125.0	175.0	250.0	300.0
X_2	4.7	12.3	26.4	67.2	159.7	298.7	430.5	645.0	831.0
Y	**12.79**	**7.72**	**5.87**	**3.61**	**2.32**	**1.81**	**1.44**	**1.16**	**1.08**
$\acute{Y}$	11.41	7.78	5.66	3.75	2.52	1.82	1.45	1.15	0.88

$\acute{Y}$ – the actual value of specific power supply

It is evident from the table that the calculated value of specific power supply differs insignificantly from its actual value. This means that the given model of multiple regression can be applied to prognosticate variations in specific power supply (Y) depending on the value of the total area under crop of the farm and the volume of output. However it is also necessary to take into account that a reasonable interpretation is possible only for certain restrictions imposed on the interpreted variables (X_1, X_2). One should not take a total small area under crop and a great volume of output, and vice versa. Everything should correspond to real values.

The obtained model of determining specific power supply allows also to carry out a qualitative estimation of the impact of the factors (X_1, X_2) discussed upon the variation (Y). The calculated coefficients in the model indicate the following: if the value of one variable, the volume of output (X_2), is left unchanged but the size of the area under crop (X_1) we increase by one unit, then the value of specific power supply will decrease by a value $-1/X_{1i}^2$, where $X_{1i} = X_1 + 1$. This decrease can be explained by the conditions created for more efficient operation of the aggregate, and consequently, decreased consumption of energy per unit of the cultivated area. If the size of the cultivated area and the volume of the production of grain per unit are fixed towards an increase, specific power supply will be set at value $1/X_{2j}^2$, where $X_{2j} = X_2 + 1$. In many respects, this can be explained by increased consumption of labour and, consequently, energy. Figures 3, 4 reflect variations in specific power supply when one of the considered factors is fixed and the other is variable.

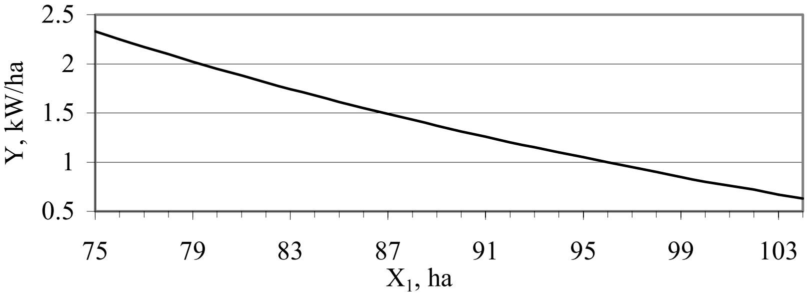

Fig. 4. **Variations in specific power supply when factor X_2 is fixed and factor X_1 is variable**

The chart in Figure 4 reflects the impact of the discussed factor – the size of the area under crop (X_1) on the variations of specific power supply (Y) when the volume of grain production is fixed X_2 = 160 t and the area X_1 under crop is from 75 ha to104 ha.

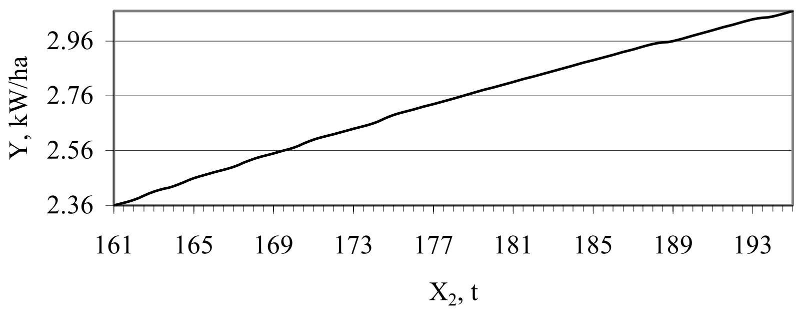

Fig. 5. **Variations in specific power supply when factor X_1 is fixed and factor X_2 is variable**

The chart in Figure 5 shows the impact of factor (X_2) – the volume of grain production upon the variations of specific power supply (Y) when the area under crop is fixed X_1 = 76 ha, and the output X_2 of grain production varies from 161 t to 194 t.

The obtained model of multiple regression provides also a possibility to determine in a quantitative way the variations in specific power supply considering any of the factors. The quantitative values of specific power supply for each range of the examined values of the areas under crop and the output of grain production are presented in Figures 4 and 5.

Increasing the size of the areas under crop lowers the specific power supply, but a rise in the output of grain production raises it only a little.

For comparison, on the Latvian farms engaged in grain production with average areas of 50 ha their specific power supply is 3.02 kW/ha but with average areas of 175 ha – 1.45 kW/ha. In the industrial countries with an average size of areas over 100 ha (agricultural land) their specific power supply is: in Canada, the USA, Australia ... – 0.35 kW/ha, in Central and Eastern Europe –1.06 kW/ha. On the small farms of Japan and Western Europe – 9.18 kW/ha [4, 5].

Conclusions

1. During the recent years the purchase of up-to-date tractors made in the EU countries is increasing.
2. The tractors put out during the last 6 years make 13.3% of the total number of tractors which are in good condition (the last checkup).
3. The analysis of the impact of the size of the areas under crop on the farm and the volume of the output upon specific power supply reveals that the level of specific power supply decreases if the total area under crop increases but it increases when the volume of the output rises.
4. The index of specific power supply can also be used for the estimation of the consumption of energy and, consequently, the impact upon the natural environment on farms having the same structure of production.

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