Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. XLVI 2016

ETHODOLOGY FOR ESTIMATING FUEL CONSUMPTION AND PRODUCTION NORMS (WORKING CAPACITY) BY POWER CLASSES, DEPENDING ON THE AGRICULTURAL WORK IN HILLY AREAS

CUJBESCU D.[1)], MATACHE M.[1)], BOLINTINEANU GH.[1)], DANCIU A.[1)], VOICEA I.[1)], VLAD C.[2)], GĂGEANU I.[1)], VLĂDUŢ V.[1)]

[1)]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, INMA, Bucharest, Romania; [2)]ICEADR Bucharest / Romania

E-mail: dcujbescu@yahoo.com

Keywords: **power source, farm, power indices, working speed**

ABSTRACT

The paper presents the results of researches conducted for determining a frame methodology for estimating fuel consumption and production norms, at national level, depending on the existing power sources, their power classes correlated with the existing surfaces at farmers and the agricultural works that need to be conducted in hilly areas in Romania, for the works of ploughing, harrowing and preparing the seedbed with rotating harrows.

INTRODUCTION

Agriculture constitutes since ancient times and continues to remain today a vital activity domain for humans. It remains the only source of food, an important provider of raw material for the industry and at the same time an important market for distributing its production.

Agricultures is a branch of material production in which, with the help of green plants and under the guiding human action, takes place the transformation of the sun's kinetic energy into potential energy – organic matter, the only form of energy accessible to human and animal bodies.

The relative importance of agriculture differs from a country to another, but it is maintained as main branch of the national economy in all states including the strongly developed ones. The experience of last decades has demonstrated that the problems of world economy cannot be solved disregarding agriculture.

Agriculture development is influenced by natural, technical and social-economical factors.

Out of the natural factors, climate has an essential part, conditioning the spreading and the structure of agricultural crops through the regime of temperature, moisture and light. Landscape influences the distribution of crops by altitude, slope exposure, slope inclination. The genetic soil type brings its contribution by its main feature, fertility, to which is added the capacity for drainage and water retention.

Technical factors have an important part in increasing productions through mechanization, chemisation, irrigation, etc., and the social-economical ones by the capacity and the preparation degree of work force and the entire economic context in which this economy branch is developed [3,4]. As any economic activity, agricultural activity has as finality to satisfying human needs and the country's general progress.

The main functions of agriculture in the national economy are [7]:

- food function;
- social-economical function, of participating to the growing and development process;

• the function of environment protection and sustainable social-economical development.

Traditional or family agriculture is found spread on various parts of the globe, and in Romania is practiced again in all ecological areas. This agriculture system widely uses manual work and animal energy on small land surfaces, together with natural or chemical fertilization and simple crop rotation. In time, it introduced small mechanisation, pesticides and has even increased land surface but also energy inputs [1, 2]. The system, although it is capable of yielding high productions, is not economically viable and is vulnerable to exterior pressures. It is in fact the agriculture of underdeveloped and poor countries and we could fit it into the category of peasant (peasant agriculture), eco-biological farms.

Intensive or industrial agriculture represents the system of large land surfaces, with high inputs of commercial energy, endowed with diversified high technical level mechanization. It is present in developed countries, having very high yield. This system ensures raw material and fresh products in large quantities, throughout the whole year, because the productive activity is developed in open fields, orchards, vineyards and greenhouses for vegetables and flowers. Crop structure is very varied, crop rotations are modern and the technological process is lead by highly qualified specialists. The system is a big consumer of energy, fertilizers and pesticides. High yield chemized agriculture allows the choice of a large range of food in relation to the consumer's nutrient necessities and tastes – a possibility that cannot be found in the traditional system. But, the ambient agricultural environment, in the air and on the plants, is polluted in different ways and at different intensities.

Sustainable agriculture (durable) implies practicing an alternative productive activity in the broad sense of the word, through the graduate passing from the purely biological one to a sustainable and biologically integrated one [5, 6]. It must fully, but judiciously use the achievements of chemistry, machinery construction and biology to increase crop yield. The contribution of chemical fertilizers and pesticides in increasing crops shouldn't surpass 40-45%, and the idea of a sustainable agriculture consist in increasing productivity and obtaining safe and constant profits, with minimum negative effects on the environment and ensuring food safety for the population, having at the base the application of technologies diversified for the pedoclimatic specific of different areas. This implies a laborious concept that anticipates the system's complexity regarding the biological stability of plants, the preservation and protection of natural resources, but also the introduction and then generalizing for a long period of time the economically viable technologies, capable of high productions and reduced costs.

MATERIAL AND METHOD

In the context of the National Strategy for Agricultural and Rural Development for the years 2014-2020 and of the code for good agricultural practice, starting from law 37-2015 and from the situation of the tractors and agricultural machinery fleet existent at 31.12.2014 in Romania, were identified 5 main tractor classes, divided depending on the type of agricultural exploitation as follows:

Exploitation	**Tractor range [HP]**
Subsistence farms	<45
Semi-subsistence farms	46÷80
Small exploitation	81÷120
Medium exploitation	121÷200
Large exploitation	201÷360

For each tractor class were identified the tractors representative for the power range *P*, as well as the average specific fuel consumption in g/HPh (g/Kwh).

The average working speeds for each tractor class were established (minimum and maximum power tractor in the power class), for the ploughing work, depending on the statistical data available for them.

Tractor range [HP]	**Average working speed, *v* [km/h]**
I	
<45	4.14
II	
46	5.58
80	6.3
III	
81	6.84
120	7.38
IV	
121	7.74
200	8.28
V	
201	8.64
360	9

RESULTS AND DISCUSSIONS

A. Methodology for estimating fuel consumption and the production norms (working capacity) by power classes, depending on the ploughing agricultural work, in hilly areas

Ploughing is the base soil work, it is executed using the plough and consists in turning the furrow, loosening, grinding and levelling the soil. In order to achieve this operation, the plough has a long iron piece that cuts the furrow laterally and detaches it from the rest of the soil, a ploughshare that detaches the furrow at its inferior side and a mouldboard that rises and turns the furrow breaking it into smaller pieces of soil.

1. For a 100% tractor load during the ploughing work, depending on the working speed *v* was calculated the theoretical traction force *F(kN)* for each tractor class (minimum and maximum power tractor in the power class), using the formula:

$$F = \frac{P}{v};$$

2. For estimating the theoretical width *l (m)*, at three main working depths (0.2, 0.25 and 0.3 m) was chosen, for average soils, the coefficient of resistance to forwarding, having an average value of 85 kN/m^2.

$$l = \frac{F}{ka}$$

3. For estimating fuel consumption per hectare was used the following calculus formula:

$$q = \frac{Pc}{85vpl} * k_{Cd}$$

where:

q – fuel consumption (l/ha)

P – tractor nominal power (HP)

c - specific fuel consumption (g/HPh) for each tractor class (minimum and maximum power tractor in the power class).

v – average working speed (km/h)

l – working width (m)
p – skidding correction coefficient (%)
k_{cd} – coefficient for correcting fuel consumption.

For skidding was chosen an average value of 10%, and thus the working speed was balanced with a correction coefficient *p=0.9*. Also, for estimating fuel consumption per hectare in the hilly area, taking into consideration the field's slope was chosen k_{cd}=1.19.

Tractor nominal power [HP]	Diesel fuel consumption [g/kWh]	Diesel fuel consumption [g/HPh]
<45	392.7	288.75
46	357	262.50
80	347.48	255.49
81	347.48	255.49
120	342.72	252
121	333.2	245
200	310.59	228.37
201	308.21	226.62
360	297.5	218.75

4. For estimating the working capacity (productivity) *W* was used the formula:

$$W = \frac{vpl}{10} * k_{pa}$$

where:

W – working capacity(ha/h)
v – average working speed (km/h)
l – working width (m)
p – skidding correction coefficient (%)
k_{pd} –coefficient for correcting production norms.

For skidding was chosen an average value of 10%, so that the working speed was balanced with a correction coefficient *p*=0.9. Also, for estimating fuel consumption per hectare in the hilly area, taking into consideration the field's slope was chosen k_{cd}=0.84.

B. Methodology for estimating fuel consumption and the production norms (working capacity) by power classes, <u>depending on the harrowing agricultural work using disk harrows</u>, in hilly areas

Harrowing is the base field work that performs soil surface levelling, loosening and grinding in the view of sowing.

1. For an 80% tractor load during the harrowing work, depending on the working speed *v* was calculated the theoretical traction force *F* for each tractor class, (minimum and maximum power tractor in the power class) using the formula:

$$F = \frac{0.8P}{v};$$

2. For estimating the theoretical working width *l*, at the working depth (0.1) was chosen for average soil the coefficient of resistance to forwarding having a value of *k*=60 kN/m^2, taking into consideration that the harrowing works takes place after the ploughing work.

$$l = \frac{F}{ka}$$

3. For estimating fuel consumption per hectare was used the following calculus formula:

$$q = \frac{Pc}{85vpl} * k_{cd}$$

where:

q = fuel consumption (l/ha)
P = tractor nominal power (HP)
c = specific fuel consumption (g/HPh) for each tractor class, (minimum and maximum power tractor in the power class).
v = average working speed (km/h)
l = working width (m)
p = skidding correction coefficient (%)
k_{cd} = correction coefficient for fuel consumption.

For skidding was chosen an average value of 5%, so that the working speed was balanced with a correction coefficient *p*=0.95. Also, for estimating fuel consumption per hectare in the hilly area was chosen k_{cd}=1.19

Tractor nominal power [HP]	Diesel fuel consumption [g/kWh]	Diesel fuel consumption [g/HPh]
<45	362.95	266.87
46	357	262.50
80	346.29	254.62
81	334.39	245.87
120	304.64	224
121	297.5	218.75
200	291.55	214.37
201	285.6	210
360	282.03	207.37

4. For estimating the working capacity (productivity) *W* was used the formula:

$$W = \frac{vpl}{10} * k_{pd}$$

where:

W – working capacity (ha/h)
v – average working speed (km/h)
l – working width (m)
p – skidding correction coefficient (%)
k_{pd} - coefficient for correcting the production norms.

For skidding was chosen an average value of 5%, so that the working speed was balanced with a correction coefficient *p*=0.95. Also, for estimating fuel consumption per hectare in the hilly area was chosen k_{cd}=0.84.

C. Methodology for estimating fuel consumption and the production norms (working capacity) by power classes, <u>depending on the agricultural work of preparing the seedbed using the rotating harrows</u>, in hilly areas

Seedbed preparation using rotating harrows represents the base soil work which has the role of performing various soil grinding and loosening works and of creating optimal conditions for uniform sowing and plant emergence.

1. For an 80% tractor load during the seedbed preparation work, depending on the working speed *v* was calculated the theoretical traction force *F* for each tractor class, (minimum and maximum power tractor in the power class) using the formula:

$$F = \frac{0.8P}{v};$$

2. For estimating the theoretical working width *l*, at the working depth (0.25) was chosen for average soil the coefficient of resistance to forwarding having a value of *k*=60 kN/m^2, taking into consideration that the seedbed preparation work takes place after the works of ploughing and harrowing.

$$l = \frac{F}{ka}$$

3. For estimating fuel consumption per hectare was used the following calculus formula:

$$q = \frac{Pc}{85vpl} * k_{Cd}$$

where:

q – fuel consumption (l/ha)
P - tractor nominal power (HP)
c - specific fuel consumption (g/HPh) for each tractor class, (minimum and maximum power tractor in the power class).
v – average working speed (km/h)
l – working width (m)
p – skidding correction coefficient (%)
k_{cd} - correction coefficient for fuel consumption.

For skidding was chosen an average value of 5%, so that the working speed was balanced with a correction coefficient *p*=0.95. Also, for estimating fuel consumption per hectare in the hilly area was chosen k_{cd}=1.19

Tractor nominal power [CP]	Diesel fuel consumption [g/kWh]	Diesel fuel consumption [g/CPh]
<45	362.95	266.87
46	357	262.50
80	346.29	254.62
81	334.39	245.87
120	304.64	224
121	297.5	218.75
200	291.55	214.37
201	285.6	210
360	282.03	207.37

4. For estimating the working capacity (productivity) *W* was used the formula:

$$W = \frac{vpl}{10} * k_{pd}$$

where:

W – working capacity (ha/h)
v – average working speed (km/h)
l – working width (m)
p – skidding correction coefficient (%)
k_{pd} - coefficient for correcting the production norms.

For skidding was chosen an average value of 5%, so that the working speed was balanced with a correction coefficient *p*=0.95. Also, for estimating fuel consumption per hectare in the hilly area was chosen k_{cd}=0.84.

CONCLUSIONS

Farm profitability depends on obtaining yields as big as possible, with costs as small as possible for agricultural works, seeds, phyto-sanitary treatments, etc., this being obtained only through an increased efficiency when performing agricultural works.

Taking into consideration that the price of seeds and of other materials used for fertilizing, spraying, etc. didn't decrease but were maintained at the same level or have increased, cost reduction depends mostly on making agricultural works more efficient.

Increasing the efficiency of agricultural works depends on the optimal choice and use of the energy source – the tractor, used for performing those works, an optimal choice leading to reduced operating costs.

Developing a general (frame) method for determining fuel consumption is very useful for dimensioning the budget and optimizing corresponding works that need to be performed buy the farmer and estimating diesel fuel consumption when performing agricultural works in the hilly areas of Romania.

The method presented in this paper is precise enough, but its precision is influenced by the coefficients that need to be experimentally determined for each representative tractor range.

ACKNOLEDGEMENT

This paper was financed by support of MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT, program ADER 13.1.3.

BIBLIOGRAPHY

[1.] **Fodor A. N.,** 2011, Researches on optimizing the maintenance of agricultural tractors, Doctoral Thesis, Braşov;

[2.] **Grisso R.,** 2014, *Predicting Tractor Diesel Fuel Consumption*, Virginia Cooperative Extension, 442-073 (BSE-175P);

[3.] **Pintilie C.,** 1985, *Agrotechnics*, Didactic and Pedagogical Publishing House, Bucharest;

[4.] **Popescu S., Bădescu M**., 1992, *Diagnosing and technical maintenance of tractors*, Bucharest, Ceres Publishing House;

[5.] **ASABE**. 2006. ASABE Standards: *Agricultural Machinery Management Data*. ASAE EP496.3, FEB 2006;

[6.] **ASABE. 2011**. ASABE Standards: *Agricultural Machinery Management Data*. ASAE D497.7, March 2011;

[7.] **Uceanu E., Bolintineanu Gh., Vlăduţ V.,** 2008, *Researches regarding the identification of qualitative characteristics at the soil work*, INMATEH I - 2008, vol. I, pp. 67-79, Bucharest.