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IMPORTANCE OF ECONOMIC EFFICIENCY IN CHOOSING FERTILISER AGGREGATES

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Abstract

The purpose of this paper is to test the aggregates chosen for an efficient application of granulated chemical fertilisers of different types during the optimal period, as well as to reduce the time and costs required for the agricultural work performed. The experiments were carried out within the IF Raicsics Mihailo Dragan Farm in the Commune of Sânpetru Mare, Timiș County, Romania. Depending on the capacity of the fertiliser hoppers of these machines, we chose the tractor with which to work in the aggregate. Obtaining high-quality crops at the lowest possible costs can only be achieved through the application of specific, perfected technologies, which allow a superior utilisation of both natural resources and inputs. Therefore, comparing the fertiliser machines studied, we notice a difference in terms of direct costs due to the technological characteristics of each one. That is why it is very important to calculate the economic efficiency of the types of aggregates chosen for different agricultural works.

Key words: *economic efficiency, fertilising aggregates, fertilisers*

INTRODUCTION

Equipping a modern and sustainable agriculture according to the experience of leading countries in this field is done with a wide range of machines and installations, of which the machines that constitute the energy base are of great importance and economic efficiency [25], [23]. Agriculture should become much more productive and much more sustainable in order to face the continuously growing demands [2], [10]. Solving the future problems of agriculture involves the use of high-yield tractors, as well as complex aggregates capable of solving the large volume of mechanized works on time and with increased efficiency [22]. Machines and equipment for applying solid mineral fertilizers are used for spreading on the soil surface or distributing and incorporating into the soil quantities of fertilizers or amendments according to agrotechnical requirements [11]. The machines and equipment should ensure compliance with the fertilizer norm, achieving uniformity of distribution and incorporation at the required depth [14], [19]. The execution of agricultural works with mechanized means contributes, in a decisive way, to the increase of the productivity of agricultural works, because they give the possibility of carrying out the works in due times and of superior quality [17], [5]. The execution of agricultural works in optimal terms and with as little costs as possible depends, to a large extent, on the working capacity of the aggregates used [13].

The administration of fertilizers and amendments at optimal times contributes to an increase in agricultural production [4]. On the other hand, fertilizers can represent an important cost, and their efficient distribution is more and more important in obtaining a high production at the lowest possible costs [20]. Fertilizers are inorganic and organic chemical substances that have the role of enriching the soil and, therefore, the vegetation with nutrients (phosphorus, nitrogen, potassium, etc.), indispensable for the growth and development of plants, while amendments are mineral substances (limestone, marl) in the form of dust or granules, which have the role of maintaining or correcting the physical structure of the soil [16]. The machines for the administration of fertilizers and amendments are intended for spreading on the soil surface or for incorporating into the soil adjustable quantities of mineral or organic fertilizers, uniformly distributed over the surface area [21], [18].

In today's conditions, most agricultural producers use complex chemical fertilizers, particularly fertilizers that have nitrogen as their active substance [1], [7]. Improper storage and use of chemical nitrogen fertilizers can cause serious harm and poisoning to humans and animals [24], [9]. The irrational use of fertilizers causes an excess of nitrogen and phosphates to appear, which has a toxic effect on the microflora in the soil and leads to the accumulation of these elements in the vegetation [15], [6].The limit between deficiency and excess of an element is difficult to estimate, everything depending on the nature of the plants and the environment [3], [12].

The purpose of this paper is to test the aggregates chosen for an efficient application of granulated chemical fertilisers of different types during the optimal period, as well as to reduce the time and costs required for the agricultural work performed.

MATERIALS AND METHODS

The studies whose results are presented in this paper were carried out in the Commune of Sânpetru Mare, Timiș County, Romania, at the IF Raicsics Mihailo Dragan Farm, established in 2014. The studies refer to the comparison of aggregates for the application of granulated chemical fertilisers on the farm. Fertiliser spreading works were carried out with the following machines:

<u>SAME 60 tractor + mounted fertiliser spreader ZA-M 1001</u>

The SAME 60 tractor is an universal tractor equipped with a mechanical transmission and with a four-cylinder diesel engine, with the following operational parameters: Nominal power Pm = 60 HP = 45 kW; Nominal engine speed nm = 1,800 rpm; Nominal motor moment Me = 26 daNm; Hourly fuel consumption Gh = 10.5 kg/h;

Specific fuel consumption gs = 175 g/CPh;

Weight G = 3,620 daN; Wheelbase L = 2.4 m; Drive wheel radius r = 0.74 m.

<u>Deutz-Fahr 150 tractor + mounted fertiliser spreader ZA-V 1400</u>

The DEUTZ-FAHR 150 tractor has the following operating parameters: Nominal power Pm = 150 HP = 112 kW; Nominal engine speed nm = 2,300 rpm; Nominal motor torque Me = 57 daNm; Hourly fuel consumption Gh = 24 kg/h;

Specific fuel consumption Gs = 190 g/CPh;

Weight G = 5,700 daN;

Drive wheel radius r = 0.78 m; 4 x 4 all-wheel drive; Independent power take-off with a speed of 1,000 rpm;

Hydraulic lifter with a maximum lifting capacity of 4,600 kg.

The force of resistance to the idle movement of the tractor is: $F_r = f \cdot G = 0.05 \cdot 5{,}700 = 285$ daN

The tractor's maximum adhesion force is determined by the relationship:

$$F_{\max} = \mu_a \cdot G \cdot = 0.7 \cdot 5{,}700 = 3{,}990 \text{ daN}$$

The traction force of the DEUTZ-FAHR 150 tractor is:

$$F_t = F_{\max} - F_r = 3{,}990 - 285 = 3{,}705 \text{ daN}$$

<u>John Deere 6930 tractor + ZA-TS 4200 mounted fertiliser spreader</u>

The John Deere 6930 tractor has the following operating parameters:

Nominal power Pm = 163 HP = 120 kW; Nominal engine speed nm = 2,100 rpm; Nominal motor torque Me = 62 daNm; Displacement – 6.8 l;

Weight G = 6,300 daN.

The force of resistance to the idle movement of the tractor is:

$$F_r = f \cdot G = 0.05 \cdot 6{,}300 = 315 \text{ daN}$$

The tractor's maximum adhesion force is determined by the relationship:

$$F_{\max} = \mu_a \cdot G \cdot = 0.7 \cdot 6{,}300 = 4{,}410 \text{ daN}$$

John Deere 6930 Tractor Traction Force is:

$$F_t = F_{\max} - F_r = 4{,}410 - 315 = 4{,}095 \ daN$$

<u>John Deere 6190R tractor + trailed fertiliser spreader ZG-B 5500</u>

The John Deere 6190R tractor has the following operating parameters:

Nominal power of the Power Tech PVX diesel engine: Pm = 190 HP = 140 kW; Nominal engine speed Nm = 1,900 rpm; Nominal motor torque Me = 71 daNm; Hourly fuel consumption Gh = 27.3 kg/h; Specific fuel consumption Gs = 195 g/kWh; Weight G = 7,700 daN.

The resistance force to the idle movement of the John Deere 6190R tractor is:

$F_r = f{\cdot}G = 0.05{\cdot}7{,}700 = 385\ daN$

The maximum adhesion force is calculated with the relation: $F_{max} = \mu_a{\cdot}R_2{\cdot}G = 0.7{\cdot}7{,}700 = 5{,}390\ daN$

John Deere 6190R tractor traction force is:

$F_t = F_{max} - F_r = 5{,}390 - 385 = 5{,}005\ daN$

Fendt 824 tractor + trailed fertiliser spreader ZG-TS 10001

The Fendt 824 tractor has the following operating parameters:

Nominal power Pm = 240 HP = 180 Kw; Nominal speed of the engine nm = 1,900 rpm; Nominal engine torque Me = 86 daNm; Weight G = 8,200 daN.

It is equipped with two gearboxes (Turboshift hydrostatic gearbox with reverse + 6-speed mechanical gearbox) and can achieve several 44 forward and reverse speeds (24 fast speeds + 20 slow speeds).The resistance force to the idle movement of the Fendt 824 tractor is:

$F_r = f{\cdot}G = 0.05{\cdot}8{,}200 = 410\ daN$.

The maximum adhesion force is calculated with the relation: $F_{max} = \mu_a{\cdot}R_2{\cdot}G = 0.7{\cdot}8{,}200 = 5{,}740\ daN$

The tractive force of the Fendt 824 tractor is:

$F_t = F_{max} - F_r = 5{,}740 - 410 = 5{,}330\ daN$ [8].

RESULTS AND DISCUSSIONS

The Amazone ZA-M 1001 fertiliser machine works in aggregate with the SAME 60 tractor. It is a machine carried and operated from the tractor's PTO shaft.

The technical characteristics of the ZA-M 1001 machine are: Weight (loaded) = 2,200 daN;

Fertiliser bin capacity = 1,000 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Spreading width = 8 m; Mass of the car = 309 kg; Number of spreading discs = 2 pcs;

Speed of the spreading discs = 720 rpm.

The spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.

Considering the agrotechnical requirements for mechanical fertilising with chemical fertilisers and the traction force of the tractor, fertilisation was carried out at a speed of 6 km/h, the aggregate using the shuttle method.

The hourly productivity of the aggregate to be fertilised is determined using the relationship:

$W_h = 0.1{\cdot}B_l{\cdot}V_l{\cdot}K\ [ha/h]$

where:

B_l = 8 m, the fertiliser spreading width;

V_l= 6 km/h, the speed at which the work is carried out;

K = 0.8, the working time utilisation coefficient.

By substitution in the relation below, we get:

$W_h = 0.1{\cdot}8{\cdot}6{\cdot}0.8 = 3.84\ ha/h$

Therefore, the daily productivity of the aggregate to be fertilised, for 8 hours worked, will be:

$W_Z = 8{\cdot}W_h = 30.72\ ha/day$

Diesel consumption for fertilising one hectare was determined as follows. In the morning, before starting working, the tank was filled with diesel. In the evening, they filled up with diesel once more. The difference represents the daily consumption (C_Z = 74 l) for the fertilised area of 32 ha. Diesel consumption per hectare was determined as follows:

$D_{Cha} = C_Z/W_Z = 74/30.72 = 2.40\ l/ha$

Direct costs D_C for fertilising one hectare include: Wage costs W_C; Fuel costs F_C; Technical maintenance costs M_C; Overhead charges costs OC_C.

A salary of 4,000 RON/month for 160 hours of work corresponds to 25 RON/h. The hourly productivity is 4 ha/h, so the remuneration will be:

$W_C = 25\ lei/4\ ha = 6.25\ RON/ha$

Fuel costs F_C;

Considering that the price of diesel is 7 RON/l, the fuel costs are:

$Fc = 7{\cdot}2.40 = 16.8\ RON/ha$

Technical maintenance costs and depreciation costs represent part of the value of the tractor and fertilising machines. On average, they are about 30% of the value of diesel, respectively 4 RON.

Therefore, direct costs are:

$D_C = W_C + F_C + M_C + A_C =$
$6.25 + 16.8 + 1 + 3 = 27.05\ RON/ha$

The Amazone ZA-V 1400 fertiliser machine works in aggregate with the Deutz-Fahr 150 tractor, being carried and operated from the tractor's PTO shaft.

The technical characteristics of the ZA-V 1400 machine are: Weight (loaded) = 3,700 daN;

Fertiliser bin capacity = 4,000 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 17 m.

The spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.

The movement speed of the aggregate to be fertilised was 8 km/h, and the spreading width of the fertilisers was 17 m.

Hourly productivity was determined with the help of the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 17 \cdot 8 \cdot 0.8 = 10.88$ ha/h

Therefore, the daily productivity of the aggregate to be fertilised, for 8 hours worked, will be:

$W_Z = 8 \cdot W_h = 87.04$ ha/day

Daily fuel consumption was 170 l of diesel. It means that for one fertilised hectare the average diesel consumption was:

$C_{ha} = 170$ l/87.04 ha=1.95 l/ha.

Remuneration costs were:

$W_C = 25$ RON/ha x 10 ha/h = 2.5 RON/ha,

Fuel costs were:

$Fc = 7 \cdot 1.95 = 13.65$ RON/ha.

To these costs are also added the costs for technical maintenance and depreciation, which were 5 RON/ha.

The direct costs of the mechanised fertilisation with the Amazone ZA-V 1400 machine, for one hectare are:

$D_C = W_C + F_C + M_C + A_C = 2.5 + 13.65 + 1 + 4 = 21.15$ RON/ha.

The Amazone ZA-TS 4200 fertiliser machine works in aggregate with the John Deere 6930 tractor. It is a machine carried and operated from the tractor's PTO shaft. The technical characteristics of the ZA-TS 4200 machine are:

Weight (loaded) = 4,900daN;

Fertiliser bin capacity = 4,200 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 36 m.

The 2-vane spreading disc is driven from the tractor's PTO shaft.

The fertiliser dispenser is electrically operated. Considering the agrotechnical requirements for mechanical fertilisation with chemical fertilisers and the traction force of the tractor, the fertilisation was carried out at a speed of 10 km/h, on a width of 36 m, the aggregate using the shuttle. Hourly and daily productivity was determined with the help of the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 36 \cdot 10 \cdot 0.8 = 28.8$ ha/h.

$W_Z = 8 \cdot W_h = 230.4$ ha/day

Daily fuel consumption was 400 l of diesel. It means that for one fertilised hectare the average diesel consumption was:

$C_{ha} = 400$ l/230.4 ha= 1.73 l/ha

Remuneration costs were:

$W_C = 25$ RON/hx 28 ha/h = 0.89 RON/ha

Fuel costs were:

$F_C = 7 \cdot 1.73 = 12.11$ RON/ha

Technical maintenance and depreciation costs were 4.3 RON/ha.

The direct costs of the fertilisation per hectare are:

$D_C = W_C + F_C + M_C + A_C = 0.89 + 12.11 + 1.3 + 4.3 = 18.6$ RON/ha

The Amazone ZG-B 5500 fertiliser spreader is a towed machine and driven from the PTO shaft of the John Deere 6190R tractor with which it works in aggregate.

The technical characteristics of the ZG-B 5500 machine are:

Weight (loaded) = 8,500daN;

Fertiliser bin capacity = 5,500 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 36 m.

The machine is equipped with two spreading discs.

The operation of the spreading discs is done from the tractor's PTO shaft through cardan transmission and gearbox.

The fertiliser dispenser is electrically operated. The transport wheels have high inflation tires to reduce ground pressure and ground settlement.

The large volume of the fertiliser bin allows fertilising with granulated mineral fertilisers over a large area.

The mechanised work with the aggregate to be fertilised was carried out at a speed of 12 km/h, the spreading width was 36 m.

With these primary data, the hourly productivity of the aggregate to be fertilised was calculated, using the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 36 \cdot 12 \cdot 0.8 = 34.56$ *ha/h*

Daily productivity was:

$W_Z = 8 \cdot W_h = 276.48$ *ha/day*

In one working day, the tractor consumed 460 l of diesel. So, when fertilising the surface of one hectare, the fuel consumption was:

$C_{ha} = 460$ *l/276.48 ha= 1.66 l/ha*

Remuneration costs were:

$W_C = 25$ *RON//h x /34 ha/h = 0.73 RON/ha*

Fuel costs were:

$F_C = 7 \cdot 1.66 = 11.62$ *RON/ha*

Technical maintenance costs were 1 RON/ha.

The depreciation costs were 3 RON/ha.

Therefore, for the fertilisation with the aggregate tractor John Deere 6190R + the machine Amazone ZG-B 5500, the direct costs for one hectare are:

$D_C = W_C + F_C + M_C + A_C = 0.73 + 11.62 + 1 + 3 = 16.35$ *RON/ha*

The Amazone ZG-TS 10001 fertiliser machine works in aggregate with the Fendt 824 tractor. It is a towed machine driven from the tractor's PTO shaft.

The technical characteristics of the ZG-TS 10001 machine are as follows:

Weight (loaded) = 12,500 daN;

Fertiliser bin capacity = 10,000 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 50 m.

The 2-vane spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.

Considering the agrotechnical requirements for mechanical fertilisation with chemical fertilisers and the traction force of the tractor, fertilisationwas carried out at a speed of 15 km/h, at a spreading width of 50 m, the aggregate using the shuttle method.

The hourly productivity of the aggregate to be fertilised is determined using the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 50 \cdot 15 \cdot 0.9 = 67.5$ *ha/h*

The daily productivity, for 8 hours worked is

$W_Z = 8 \cdot W_h = 540$ *ha/day*

The average diesel consumption for a fertilised hectare was 1.5 l/ha.

The direct costs of the mechanised fertilisation include:

Remuneration costs:

$W_C = 25$ *RON/h x 34 ha/h = 0.7 RON/ha*

Fuel costs:

$F_c = 7 \cdot 1.5 = 10.5$ *RON/ha*

Technical maintenance costs were 1.6 RON/ha.

The amortization costs were 3 RON/ha. So, the direct costs of the work have the value:

$D_C = W_C + F_C + M_C + A_C = 0.7 + 10.5 + 1.6 + 3 = 15.8$ *RON/ha.*

CONCLUSIONS

This paper presents a study on aggregates fertilizing with granulated chemical fertilizers. When establishing agricultural aggregates with direct tractor-agricultural machine reference, the energy source should be rationally loaded using machines with high work capacity so that energy consumption is as low as possible.

Thus:

Amazone fertilizing machines, through the wide range of construction types, fully ensure the mechanization of fertilizations, both for small and large farms, meeting the following main requirements:

Superior work quality indices, corresponding to the agrotechnical requirements of modern agriculture;

High working capacity;

Rational use of energy sources by optimally loading the tractors from the aggregate;

High reliability at a low-cost price;

Convenience of service (driving, adjustments, maintenance), requires minimal service personnel;

Security of the service staff's work.

Therefore, comparing the fertiliser machines studied, we notice a difference in terms of direct costs due to the technological characteristics of each one. That is why it is very important to calculate the economic efficiency of the types of aggregates chosen for different agricultural works.

The Amazone ZG-TS 10001 fertiliser machine stands out for the following performances:
Large capacity of the bin allows a high autonomy;
Large spreading width ensuring high productivity and low diesel consumption;
Regulation of the fertiliser rate per hectare within broad limits thanks to the high flow rate of the dispenser which can reach the value of 650 kg/min. All these facilities lead to a decrease in direct costs for fertilizing one hectare, compared to other fertilizing machines.
The main problem of a rational mechanization technology is to ensure the most judicious correlation of works and machines on the entire technological process to obtain the product with the lowest labour costs and energy consumption. The use of modern technologies of mechanization, chemicalization, and fertilization, the use of varieties suitable for different types of technologies have a great efficiency from an economic point of view, in the sense that higher productions are obtained with reduced costs with reference to fuel consumption and, not least, in order to perform the work during the optimal mechanization period.

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