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DETERMINING THE ECONOMIC EFFICIENCY OF APPLYING A COMBINED PLOUGH

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Abstrakt: Currently, various methods are used to apply fertilizer under the plow. At the same time, mineral fertilizers are applied to the soil surface after harvesting in our republic with Amazone ZA M-1500 brand disc centrifugal fertilizer spreaders. Immediately after sowing, the plowing operation is carried out with an SP-12 brand four-body plough so that the applied fertilizers fall under the soil. This is how the operation is performed. The tractor is used twice to carry out this technological operation, which is economically inefficient and inconvenient on slopes. Thus, the centrifugal fertilizer spreader works unevenly. To eliminate this problem, a combined plough was developed in our laboratory. In order to calculate the economic efficiency of the combined plough, the economic indicators of the SP-12 brand four-body plough and the Amazone ZA M-1500 brand fertilizer spreader were compared, and an economic efficiency of 1586.79 AzN (933.41, dollars \$) was obtained. The article provides economic tables. The smooth and even distribution of mineral fertilizers in the field with the application of a combined plough increases the yield in grain growing from 26 cent/ha to 32 cent/ha minimally.

If we calculate the cost of wheat at about 0.35 AzN (0.21 dollars,\$) (per kg, then with 600 kg per hectare, it allows to obtain an economic yield of 210 AzN/ ha (123.53 dollars/ha), and an economic yield of 68040 AZN (40,023.53 dollars \$) from 324 ha during the season.

Key words: *Combined plough, economic efficiency, fertilizer, fertilizer spreader, plow*

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INTRODUCTION

In the cultivation of cereals on slopes, the application of equal amounts of mineral fertilizers to the soil before sowing is a very important technological process [5],[14]. The low level of technical equipment in this area prevents producers from providing the republic with cereals of the required quality.

In mountain farming, to prevent excessive soil compaction and reduce fuel consumption, it is considered efficient to perform several operations on slopes with a combined unit in one pass of the tractor. At the same time, combining plowing operations with the application of fertilizers in equal amounts to the plowing soil gives greater economic efficiency. In the laboratory of the Scientific Research Institute "Agromekhanika", a combined plough was developed that applies mineral fertilizer to the under plow (Fig. 1).



Figure 1. Combined plough

As can be seen from the figure, two ATP-2 fertilizer spreaders are mounted on the four-body plough (figure 1). The devices are driven by the support wheel of the plough. The fertilizer spreading rate is regulated by changing the sprockets. The technological process of the combined plough is shown in figure 1. The combined plough consists of two ATP-2 fertilizer spreaders mounted on a Turkish-made SP-12 4-body plough [6].

The fertilizer spreaders are driven by the support wheel of the plough through chain drives.

The support wheel is equipped with spurs (reborda) to prevent slipping. The fertilizer spreaders, driven by the support wheel, deliver fertilizer to the plow through four fertilizer transfer pipes [3],[7],[8]. To ensure uniform fertilizer distribution, a smooth spreader is attached to the outlet of the pipes. The use of a combined plough completely reduces the operation of spreading fertilizer with fertilizer spreaders before plowing, the costs and labor costs, and at the same time ensures high efficiency of fertilizer use, i.e., applying fertilizer to the soil prevents its loss, ensures uniform scattering, etc.

In addition, time is saved significantly and it becomes possible to perform operations in a short time.

To determine the economic efficiency of the experimental model of the machine for applying solid mineral fertilizers to the plow, we used economic evaluation methods - GOST P 53056-2008 and literature sources to calculate technical and economic indicators.

For the criterion of the economic efficiency of the machine, the economic effect obtained as a difference for the compared variants of the machines, reduced costs for the implementation of the annual volume of work and the amount of product production are taken [1],[10],[13].

MATERIALS AND METHODS

Considering that currently there is no combined plough produced in the industry, we took the performance of the SP-12 four-body plough and the Amazone-1500 fertilizer spreader as a basis for comparison [9].

As initial data for calculations, normative data and results of technical work on the cultivation of cereals were taken. Seasonal costs (P) associated with the application of any technique are determined by the following formula [4]:

$$P = \dot{I} + KE; \quad \dots\dots\dots (1)$$

Where:

I - seasonal operating costs associated with the use of technical equipment, dollars (\$);

E - is a normative coefficient and indicates the efficiency of investment, $E = 0.25$

K – capital investment required for the acquisition of technical equipment, dollars.

Seasonal operating costs (I) related to the use of technical equipment include the following costs:

$$\dot{I} = Z + A + R_k + R_m + C + X \quad \dots\dots\dots (2)$$

Where:

Z – seasonal wages of employees operating the technical vehicle, AzN (dollars \$);

A – depreciation allowances for the use of the technical vehicle, AzN (dollars \$);

R_k - capital repair costs, AzN (dollars \$);

R_m – allowances for current repairs and maintenance of the tractor and combined harvester,

C - cost of fuel and lubricants, AzN (dollars \$);

X – total costs per work unit, AzN (dollars \$)

Cost of wages of service employees, AzN (dollars \$)

$$Z = n_1 t_1 C D \quad \dots\dots\dots (3)$$

Where:

n_1 - number of employees providing services;

t_1 - working hours per day; $t_1 = 7$ hours;

C - hourly labor cost of an employee, $C = 3.5$ AzN (2.06, dollars \$),

D - number of working days in a season, $D = 64$ days

Hourly labor costs are calculated using the following formula:

$$Z_o = \frac{N}{w_s}, \quad \text{AzN-hour (dollar \$-hour) / h} \quad \dots\dots\dots (4)$$

The total depreciation costs for a tractor and a combined plough are calculated using the following formulas.

$$A = A_a^t + A_a^{s.m} ; \quad \dots\dots\dots (5)$$

$$A_a^t = \frac{\zeta^t \cdot a_t}{100 W_t} ; \quad \dots\dots\dots (6)$$

$$A_a^{s.m} = \frac{\zeta^{s.m} a_{s.m}}{100 W_s} ; \quad \dots\dots\dots (7)$$

Where:

ζ^t - book value of the MTZ -1221 tractor, $\zeta^t = 66138$ AzN (38,904.71 dollars \$)

a_t – percentage of the depreciation cost of the tractor to the book value, $a_t=12,5\%$

$A_a^{s.m}$ – depreciation costs per unit of work of the machine,

$\zeta^{s.m}$ - book value of the machine,

$a_{s.m}$ – annual depreciation cost as a percentage of the book value of the machine, 14,2%

W_s – annual work volume of the machine,

W_t – annual work volume of the tractor,

$$W_t = W_z W_s ; \quad \dots\dots\dots (8)$$

Where:

W_z – annual loading of MTZ-1221 tractor, $W_z = 1700$ hours

W_s – productivity of the unit,

The productivity of the unit can be found by the following formula. ha/hour

$$W_s = 0,1 B v \tau ; \quad \dots\dots\dots (9)$$

Where:

B – working width of the machine, m

v – speed of the unit, km/h

τ – time utilization factor,

The costs allocated for major repairs per unit of tractor work are calculated as follows:.

$$R_k = R_{kt} = \frac{\zeta_t r}{100 W_t} ; \text{ AzN (dollar \$) /ha} \quad \dots\dots\dots (10)$$

Where:

r – equal to 12% of the annual interest on the tractor's major repairs,

The costs allocated for the current repair and maintenance of the tractor and combined plough are calculated using the following formula.

$$R_m = R_m^t + R_m^{s.m}; \quad \dots\dots\dots (11)$$

$$R_{mt} = \frac{C_t r_t}{100 W_t}; \quad \text{AzN (dollar \$)/ha}, \quad \dots\dots\dots (12)$$

$$R_{tm} = \frac{C_m r_m}{100 W_m}; \quad \text{AzN (dollar \$)/ha}, \quad \dots\dots\dots (13)$$

Where:

r_t – equals 27% of the expenses allocated for the current repair and maintenance of the tractor,

r_m – equals 13% of the expenses allocated for the current repair and maintenance of the gear roller,

Expenses incurred on fuel and lubricants are calculated as follows.

$$C_t = \frac{N q C_q \alpha}{100 W_t}; \quad \text{AzN (dollar \$)/ha}, \quad \dots\dots\dots (14)$$

Where:

N – nominal engine power of the MTZ-1221 tractor, $N = 120$ hp

q – fuel consumption per 1 hp kg, $q = 0.195$ kg / hp

C_q – cost of 1 liter of fuel, $C_q = 0.8$ AzN (dollar \$)

α – equal to 80% of the use of engine power in field work,

Costs are calculated by the following formula depending on the volume of work

$$X = \frac{X_t + X_m}{W_r}; \quad \dots\dots\dots (15)$$

Where:

X_t and X_m are the costs per hour of work, respectively,

$X_t = 0.39$ cents/hour; $X_m = 0.39$ cents/hour;

The economic efficiency of technological operations is calculated by the following formula.

$$E_q = P_s - P_n; \quad \text{AzN (dollar \$)}, \quad \dots\dots\dots (16)$$

Where:

P_s – imported prices of the old machine,

P_n – manufacturing costs of the new machine,

The specific capital investment in the unit is determined by the following formula.

$$K_u = \frac{C^t}{W_t}; \quad \dots\dots\dots (17)$$

RESULTS

Since the combined plough performs 2 technological operations, the above economic report was calculated for each technological operation and the comparison of the economic efficiency of the combined plough was analyzed.

Table 1. Calculation of the economic efficiency of the combined plough

№	Indicators	Unit of measure	Price AzN (\$)
1.	Productivity, W	ha/hr	0.72
	Working width, B	m	1.51
	Speed, V	km/hr	6
	Time utilization factor, τ	--	0.8
2.	Workers' wages	AzN (\$)	1568 (922.35 \$)
	Number of employees	person	1
	Working hours in a day	hr	7
	1 hour's wage	AzN (\$)	3.5 (2.06 \$)
	Number of working days in the season	day	64
3.	Annual working volume of the tractor	ha	1224
4.	Combined plough work volume	ha	324
5.	Depreciation costs per tractor working volume	AzN (\$)	675 (397.06 \$)
	MTZ-1221 tractor value	AzN (\$)	66138 (38904.71\$)
	Depreciation cost of a tractor	%	12.5
	Annual working volume of the tractor	ha	1224
6.	Depreciation costs per combined plough work volume	AzN (\$)	3.6 (2.12\$)
	Combined plough value	AzN (\$)	8195 (4820.59\$)
	Annual depreciation expense as a percentage of the combined plough value	%	14.2
	Annual workload of the combined plough	ha	324
7.	Total depreciation expense	AzN (\$)	678.6 (399.18 \$)
8.	Expenses allocated for major repairs per unit of tractor work	AzN (\$)	6.48 (3.81\$)
9.	Expenses allocated for current repairs and maintenance of the tractor and combined plough	AzN (\$)	17.89 (10.52\$)
10.	Expenses on fuel and lubricants	AzN (\$)	20.8 (12.24\$)
11.	Costs of the scope of work	AzN (\$)	1.08 (0.64\$)
12.	Total exploitation costs	AzN (\$)	2292.85 (1348.74\$)
13.	Special capital investment in combined plough	AzN (\$)	25.29 (14.88\$)
14.	Incurred expenses	AzN (\$)	2299.17 (1352.45\$)

Table 2. Calculating the economic efficiency of a four-body plough

№	Indicators	Unit of measure	Price AzN (\$)
1.	Productivity, W	ha/hr	0.72
	Working width, B	m	1.51
	Speed, V	km/hr	6
	Time utilization factor, τ	--	0.8
2.	Workers' wages	AzN (\$)	1568 (922.35 \$)
	Number of employees	person	1
	Working hours in a day	hr	7
	1 hour's wage	AzN (\$)	3.5 (2.06 \$)
	Number of working days in the season	day	64
3.	Annual working volume of the tractor	ha	1224
4.	Working volume of a four-body plough	ha	324
5.	Depreciation costs per tractor working volume	AzN (\$)	675 (397.06\$)
	The cost of the MTZ-1221 tractor	AzN (\$)	66138 (38904.71\$)
	Depreciation cost of a tractor	%	12.5
	Annual working volume of the tractor	ha	1224
6.	Depreciation costs per plough work volume	AzN (\$)	1.97 (1.16\$)
	Plough value	AzN (\$)	4500 (2647.06\$)
	Annual depreciation expense as a percentage of the cost of the plough	%	14.2
	Annual workload of the plough	ha	324
7.	Total depreciation expense	AzN (\$)	676.97 (398.22\$)
8.	Expenses allocated for major repairs per unit of tractor work	AzN (\$)	6.48 (3.81\$)
9.	Expenses allocated for current repairs and maintenance of the tractor and four-wheeled tractor	AzN (\$)	16.40 (9.65\$)
10.	Expenses on fuel and lubricants	AzN (\$)/ha	20.8 (12.24\$/ha)
11.	Costs of the scope of work	AzN (\$)/ha	1.08 (0.64\$/ha)
12.	Total exploitation costs	AzN (\$)	2289.73 (1346.9\$)
13.	Special capital investment in a four-body plough	AzN (\$)	13.89 (8.17\$)
14.	Incurred expenses	AzN (\$)	2293.20 (1348.94 \$)

Table 3. Calculation of the economic efficiency of the Amazone ZA M-1500 fertilizer spreader

№	Indicators	Unit of measure	Price AzN (\$)
1.	Productivity, W	ha/hr	5.12
	Working width, B	m	8
	Speed, V	km/hr	8
	Time utilization factor, τ	--	0.8
2.	Workers' wages	AzN (\$)	1568 (922.35 \$)
	Number of employees	person	1
	Working hours in a day	hr	7
	1 hour's wage	AzN (\$)	3.5 (2.06\$)
	Number of working days in the season	day	64
3.	Annual working volume of the tractor	ha	8704
4.	Unit working volume of fertilizer spreader	ha	2304
5.	Depreciation costs per tractor working volume	AzN (\$)	0.94 (0.55\$)
	The cost of the MTZ-1221 tractor	AzN (\$)	66138 (38904.71\$)
	The value of the depreciation cost of the tractor	%	12.5
	Annual working volume of the tractor	ha	8704
6.	Depreciation costs per unit of fertilizer production	AzN (\$)	4.84 (2.85\$)
	The cost of fertilizer spreader	AzN (\$)	11044 (6496.47\$)
	Annual depreciation expense as a percentage of the cost of the fertilizer spreader	%	14.2
	Annual working volume of the fertilizer spreader	ha	324
7.	Total depreciation expense	AzN (\$)	5.78 (3.4\$)
8.	Expenses allocated for major repairs per unit of tractor work	AzN (\$)	0.91(0.54\$)
9.	Expenses allocated for current repairs and maintenance of the tractor and fertilizer spreader	AzN (\$)	6.48(3.81\$)
10.	Expenses on fuel and lubricants	AzN (\$)/ha	2.92(1.72\$)
11.	Costs of the scope of work	AzN (\$)/ha	0.15 (0.09\$/ha)
12.	Total exploitation costs	AzN (\$)	1584.24 (931.91\$)
13.	Special capital investment in a four-body plough	AzN (\$)	34.08 (20.05\$)
14.	Incurred expenses	AzN (\$)	1592.76 (936.92\$)

The economic efficiency of technological operations is calculated using the following formula:

$$E_q = P_s - P_n = 3885.96 - 2299.17 = 1586.79 \text{ AZN (933.41\$)}$$

DISCUSSION

60% of the territory of the Republic of Azerbaijan is located in mountainous and foothill areas. In addition, taking into account the climate change taking place in the world and global warming, it is favorable to grow sustainable cereals in mountainous and foothill areas. Taking into account the above ideas and considerations, the development of mountain agriculture is one of the main goals facing us [2],[11],[12].

Considering that it is very difficult for a tractor to move on mountain slopes. Excessive slope not only reduces the tractor's maneuverability but also increases fuel consumption. It is advisable to reduce the number of tractor trips when performing 2 technological operations on slopes. We perform 2 technological operations with a combined plough in one pass of the tractor. We apply double superphosphate mineral fertilizer to the soil by plowing it. Our research shows that it is environmentally friendly to apply toxic mineral fertilizers in a single application of combined plough. Thus, toxic mineral fertilizers that fall into the under of soil do not pollute the environment.

The economic efficiency of the technological operations carried out was calculated and comparatively analyzed. The economic efficiency of the combined plough, according to comparative analyses, was 1586.79 AZN (933.41\$). Two technological operations performed with the SP-12 four-body plough and the Amazone ZA M-1500 fertilizer spreader were combined and their economic efficiency was calculated and compared with the combined plough.

Table 4. Economic comparison

№	Name of indicators	Unit of measure	Mechanization options			
			SP -12 plough	Amazone ZAM - 1500	Total transactions per unit time	Experimental Combined Plough
1.	Productivity	ha/hr	0.72	5.12	0.72	0.72
2.	Expiration date	hour	450	450	450	450
3.	Capital investment	AzN (\$)	13.89 (8.17\$)	34.08 (20.05\$)	47.97 (28,22 \$)	25.29 (14,88\$)
4.	Depreciation expenses	AzN (\$)	676.97 (398.22 \$)	5.78 (3.4\$)	682.75 (401.62\$)	678.6 (399.18\$)
5.	Current repair and maintenance costs	AzN(\$)/ha	16.40 (9.65\$)	6.48 (3.81\$)	22.88 (13.46\$)	17.89 (10.52\$)
6.	Fuel and lubricant costs	AzN (\$)/ha	20.8 (12.24\$)	2.92 (1.72\$)	23.72 (13.95\$)	20.8 (12.24\$)

Contin. Table 4.

7.	Exploitation costs	AzN (\$)	2289.7 (1346.9 \$)	1584.24 (931.91\$)	3873.97 (2278.81\$)	2292.85 (1348.74\$)
8.	Incurred expenses	AzN (\$)	2293.20 (1348.82\$)	1592.76 (936.92\$)	3885.96 (2285.86\$)	2299.17 (1352.45\$)
9	Economic efficiency	AzN (\$)	-	-	-	1586.79 (933.41\$)
10.	Economic efficiency in grain production	ha/ AzN (\$)	-	-	-	210 (123.53\$)
		kg/ha	-	-	-	600 (352.94\$)
11.	Economic efficiency during the season in grain production	AzN (\$)	-	-	-	68040 (40023.53\$)
		ton	-	-	-	194.4
12.	Overall economic efficiency	AzN (\$)	-	-	-	69626.79 (40956.94\$)

Thus, the smooth and even distribution of mineral fertilizers in the field with the application of a combined plough minimally increases the productivity in grain growing from 26 cent/ha to 32 cent/ha. If we calculate the price of wheat at approximately 0.35 AzN (0.21dollars \$) per kg, then 600 kg per hectare allows us to obtain an economic yield of 210 AzN / ha (123.53\$/ha), and 68040 AzN (40023.53 dollars \$) from an area of 324 ha during the season.

CONCLUSIONS

1. According to the economic analysis conducted, the costs incurred for technological operations performed by the combined plough, SP-12 plough, and AMAZONE ZA M-1500 fertilizer spreader were compared. The annual economic benefit of a combined plough is 1586.79 AzN (933.41 dollars \$), based on the difference in costs incurred.

2. Thus, the smooth and even distribution of mineral fertilizers in the field slopes with the application of a combined plough minimally increases the productivity in grain growing from 26 cent/ha to 32 cent/ha. If we calculate the price of wheat at approximately 0.35 AzN (0.21dollars \$) per kg, then 600 kg per hectare allows us to obtain an economic yield of 210 AzN / ha (123.53\$/ha), and 68040 AzN (40023.53 dollars \$) from an area of 324 ha during the season.

3. The use of a combined plough combines the plowing operation and the fertilizer spreading operation, saving time and ensuring that the operations are completed in a short time. Incorporating fertilizer into the soil is environmentally friendly and prevents fertilizer loss.

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UTVRĐIVANJE EKONOMSKE EFIKASNOSTI PRIMENE KOMBINOVANOG PLUGA

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Apstrakt: Trenutno se koriste različite metode za unošenje đubriva ispod radnih tela pluga. Istovremeno se mineralna đubriva na površinu zemljišta nakon žetve u našoj republici nanose centrifugalnim disk rasipačem đubriva Amazone ZA M-1500.

Odmah nakon setve oranje se vrši pomoću kombinovanog pluga marke SP-12 sa četiri radna tela, tako da primenjena đubriva budu unešena u zemljište. Za izvođenje ove tehnološke operacije traktor se koristi dva puta. To je ekonomski neefikasno i nezgodno na padinama, gde centrifugalni rasipač đubriva radi neravnomerno.

Da bi se ovaj problem otklonio, uveden je kombinovani plug, razvijen u našoj laboratoriji za mehanizaciju i biljnu proizvodnju (Ganja City).

Da se izračuna ekonomska efikasnost kombinovanog pluga, ekonomski pokazatelj pluga sa četiri tela marke SP-12 upoređen je rasipač đubriva marke Amazone ZA M-1500. Dobijena je ekonomska efikasnost od 1586,79 AzN (933.41 \$) .

U ovom radu su prikazane ekonomske tabele istraživanja. Ravnomerna distribucija mineralnih đubriva u polju sa primenom kombinovanog pluga SP-12 povećava prinos u gajenju žita minimalno sa 26 cent/ha na novu vrednost od 32 cent/ha.

Izračunata cena pšenice od približno 0.35 AzN (0.21\$) po kg, sa 600 kg po hektaru, omogućava da se dobije ekonomski prinos od 210 AzN / ha (123.53\$/ha), a ekonomski prinos od 68040 AzN (40023.53\$) sa 324 ha tokom sezone.

Ključne reči: *Kombinovani plug; ekonomska efikasnost; đubrivo; rasipač đubriva; plug*

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