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SOME SCIENTIFIC-METHODOLOGICAL ASPECTS OF AGRICULTURAL PRODUCTION EFFICIENCY

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Cost of production, fixed costs, variable costs, minimal crop yield, break-even level of production, marginal revenue, marginal profit, profitability level of production, rate of return on capital.

Annotation
The article describes the methods of computing cost of production, minimal crop yield and a break-even amount of production. It also propones the formulas for determining the increment in profit - including marginal profit due to growth in the crop yield, demonstrates graphical correlation between the crop yield and costs of production output and develops formulas of interdependence of profitability of production and sales, rate of return on investment and rate of profitability of production and sales.

Efficiency of production is a complex economic category which reflects economic principles and reveals the most important part of a company's activity – its economic efficiency.

In order to produce agricultural products, each agricultural enterprise, e.g.a collective or husbandry farm, possesses and utilizes such resources as land, current and fixed assets, certain financial resources and labor force. The use of disposable resources is collectively reflected in enterprise productivity. In its turn, increases in productivity are a major source of ensuring development of an industry or an economic sector.

Productivity can be characterized by production growth of high-quality products at minimal expenditures of labor and material resources per unit of output. As for agriculture, its essence is in yielding a maximum amount of products per hectare of land or head of domestic animals at minimal expenditures of direct and materialized labor.

Economic efficiency of agricultural production is characterized by a system of key variables, among which the most important ones are the cost of manufactured and realized production (by

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types), net profit per unit of area or per unit of production output, as well as the profitability level. Activities of agricultural enterprises which specialize in competitive products are bound to have particular expenditures. In general, expenditures reflect the types and volumes of utilized resources. Total expenditures which are linked to manufacturing production and sales and expressed in monetary terms are referred to as the total cost of production.

Cost of production is one of the most important summarizing activities of an enterprise, a mirror of efficiency in enterprise management. Production expenditures on the same volume of output can increase or decrease depending on the efficient utilization of material, land, financial and labor resources as well as on the results of innovative implementation of new equipment and progressive technology, modern management and other factors.

Thorough research of the production factors' influence on the efficiency of crop cultivation allows determining a mathematical link between the cost and the yield of crop output. For this purpose, all costs associated with production and sales of products are divided respectively into fixed costs (FC) and variable costs (VC). The latter – unlike the fixed costs – are characterized by their dependence on the level of production output. These costs are primarily associated with crop harvesting and sales.

Total costs can be presented by the formula:

$$TC=FC+VC,\ lei^{2} \qquad (1)$$

Average total costs – costs per 1 centner of production (1centner ~ 220.75 pounds) – can be estimated by dividing both parts of equation (1) by the total quantity of production output (Q):

$$\frac{TC}{Q}=\frac{FC}{Q}+\frac{VC}{Q},$$

$$ATC=AFC+AVC,\ lei/centner \qquad (2)$$

Cost of production per 1 unit (z) of production output can be expressed by the formula:

$$z=ATC=\frac{FC}{q}+AVC,\ \text{lei/centner} \qquad (3)$$

2 Moldovan currency, 1 USD ~ 12.04 Moldovan Lei as of February 4, 2013

Where FC is the fixed cost (in lei) per 1 hectare of land (1 hectare ~ 2.47 acres);
AVC is the average variable cost (lei) per 1 centner of output;
q – rate of the crop yield, centner/hectare.

Agriculture, unlike many other economic sectors, is distinguished by a high share of fixed costs in the structure of total cost of production (up to 70%-90%). That is why it is essential to maximize production output for a given level of invested resources.

Knowing the level of fixed and variable costs of output and its anticipated sales price, it is possible to forecast the break-even rate of the crop yield based on the formula:

$$q_{be} = \frac{FC}{p\text{-}AVC}, \text{ centner/hectare} \qquad (4)$$

where p is the expected sales price of production output (lei/centner).

If, for any crop cultivation technology, an agricultural specialist cannot provide a crop yield above its forecasted minimal level, it is necessary to research and consider a change of technology towards its intensification – either towards growth in the productivity of land or, otherwise, to refusal of land cultivation. However, it is important to keep in mind that any such changes require, accordingly, a computation of new fixed and variable costs and the break-even rate of crop yield. We can compute the break-even level of production output per hectare of land (Q_{be}) by multiplying the left and the right side of equation (2) by the sales price of production (p). We will thus obtain:

$$p \cdot q_{be} = \frac{FC}{1 - \frac{AVC}{p}}$$

or:

$$Q_{be} = \frac{FC}{1 - \frac{AVC}{p}}, \textit{ lei/hectare} \qquad (5)$$

An increase in sales above the break-even point leads to achieving profits whereas a decrease in sales below the break-even point – accordingly, to having losses. In the graphical method of computing the break-even level of sales R_{be} the point of intersection of the total revenue line (R) and the total costs line (TC) is called the break-even point of production output.

As we know, operating profit (earnings before interest and taxes or EBIT) per 1 centner of production is computed as the difference between the sales price and the cost per unit of output:

$$EBIT = p - z, \text{ lei/centner} \qquad (6)$$

Since the cost of production depends on fixed costs, variable costs and the rate of the crop yield (as per formula 3), then:

$$EBIT = p - \left(\frac{FC}{q} + AVC \right)$$

$$EBIT = p - AVC - \frac{FC}{q}, lei/centner \qquad (7)$$

Operating profit per one hectare of land can be computed as a product of the crop yield rate and the net profit per 1 centner of realized production output, i.e.

$$EBIT_{land} = q \cdot EBIT$$

$$EBIT_{land} = q\,(p - AVC) - FC,\ lei/hectare \qquad (8)$$

As the experience of many agricultural enterprises – which abide by the requirements of crop cultivation technology – shows, it is possible to achieve a higher production level per unit of land, and therefore higher profitability, only due to increases in the quality of cultivation and harvesting operations and other factors not associated with changes in fixed and variable costs (all else being equal).

Let us denote a standard variant of operating profit as:

$$EBIT^{stand}_{land} = q_{stand}\,(p - AVC) - FC,$$

While, respectively, a new variant of operating profit as:

$$EBIT^{new}_{land} = q_{new}\,(p - AVC) - FC.$$

Then the increment in the operating profit from 1 hectare of land will equal:

$$\Delta EBIT_{land} = EBIT^{new}_{land} - EBIT^{stand}_{land} = q_{new}(p - AVC) - FC - q_{stand}(p - AVC) + FC,$$

$$\Delta EBIT_{land} = (p - AVC)(q_{new} - q_{stand}),\ lei/hectare \qquad (9)$$

Based on formula 7 derived by the author, marginal profit or profit increment per one centner of production output caused by an increase in productivity will equal:

$$\Delta EBIT = EBIT_{new} - EBIT_{s\tan d.} = p - AVC - \frac{FC}{q_{new}} - p + AVC + \frac{FC}{q_{s\tan d.}} = FC\left(\frac{1}{q_{s\tan d.}} - \frac{1}{q_{new}}\right),$$

$$\Delta EBIT = FC\left(\frac{1}{q_{s\tan d.}} - \frac{1}{q_{new}}\right),\ \textbf{lei/centner} \qquad \textbf{(10)}$$

Marginal profit or increment in profit caused by an increase in the crop yield by 1 centner/hectare could be computed by the following formula:

$$\Delta EBIT = \frac{FC}{q^2_{s\tan d.} + q_{s\tan d.}},\ \textbf{lei/centner} \qquad \textbf{(11)}$$

$$\Delta EBIT = FC\left(\frac{1}{q_{s\tan d.}} - \frac{1}{q_{new}}\right) = FC\left(\frac{1}{q_{s\tan d.}} - \frac{1}{q_{s\tan d.} + 1}\right) = \frac{FC}{q^2_{s\tan d.} + q_{s\tan d.}}$$

Having conducted analogous mapping, it is possible to obtain a relationship for computing a decrease in operating profit given a decrease in the crop yield by 1 centner/hectare:

$$\Delta EBIT = \frac{FC}{q^2_{s\tan d} - q_{s\tan d}},\ \textbf{lei/centner}$$

(12)

As formula 3 shows, there is an inverse relationship between the cost of production and crop yield. The graph of inverse proportionality is a hyperbole: an increase in the crop yield leads to a decrease of the cost of production, and vice versa – a decrease in the crop yield leads to an increase in the costs per unit of production output.

In order to demonstrate the effect of the crop yield on the fixed and total costs of production we will perform computations according to formulas 2 and 3 and will include the results in a table. As an example, let us consider the corn production and sales data at Agro Sadim, LLC of the Comrat Administrative Region, Republic Moldova, for the 2011 fiscal year.

The input data are as follows: FC = 4,992 lei/hectare, AVC = 44.55 lei/centner, p = 298.9 lei/hectare, q = 47.7 centner/hectare.

Computed Indicators of the Cost of Production-Crop Yield Relationship for Corn at Agro Sadim, LLC for Fiscal Year 2011

Crop Yield (q), centner/hectare	Average Total Cost per 1 Centner (z), lei	Average Fixed Costs (AFC), lei/centner
10	543.8	499.2
20	294.2	249.6
30	211.0	166.4
40	169.4	124.8
50	144.4	99.8
60	127.8	83.2
70	115.9	71.3

Computed based on the FY 2011 financial report, Form No 7-APK and Form No 9-APK

The mechanism of the crop yield-cost of production relationship can be demonstrated in Figure 1. The graph shows that the average total cost of production (z) is composed of average fixed costs (AFC) and average variable costs (AVC). Let us note that along with an increase in the crop yield average variable costs remain constant whereas the average fixed costs decrease, which leads to a decrease of the average total costs (z). Equality of the sales price (p) and the average total cost of production (z) indicates a break-even crop yield. The difference between the sales price and the average variable cost demonstrates the magnitude of marginal profit (d).

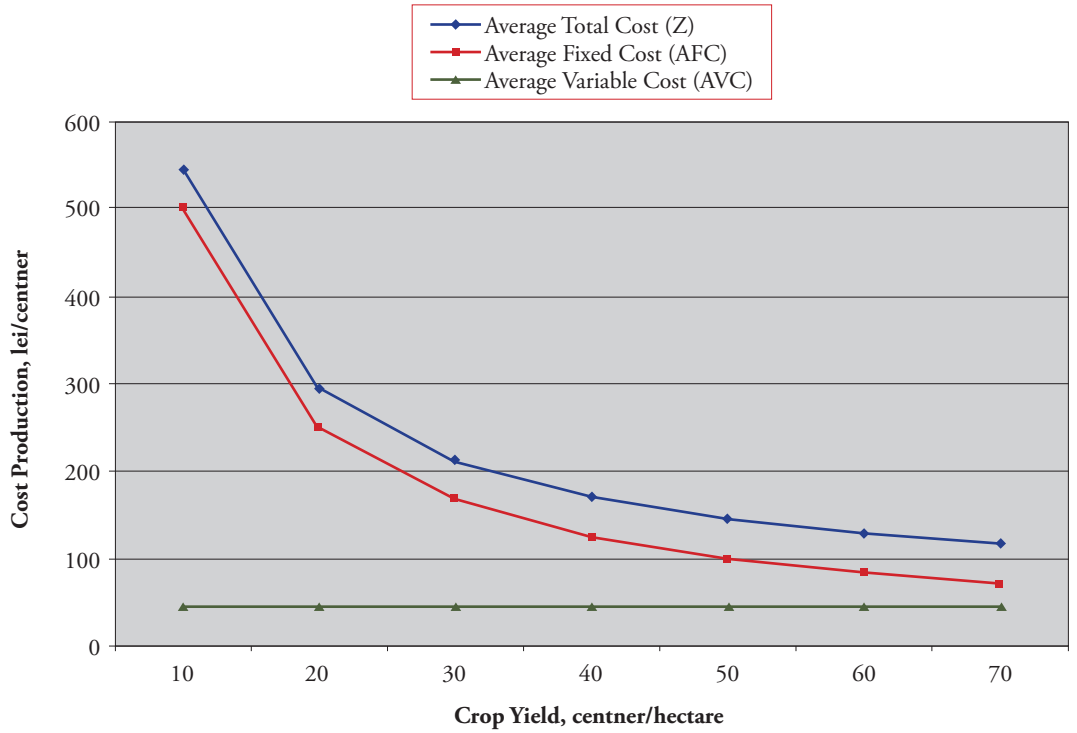

Figure 1. Mechanism of the Crop Yield-Production Cost relationship for Corn at Agro Sadim LLC for the FY 2011

Source: Agro Sadim, LLC Annual Report 2011, Form 7-APK and 9-APK

According to formula 7, an increase in crop yield leads to an increase in operating profit per 1 centner of production output. Such relationship can be characterized graphically by an upward-sloping line (Figure 2).

Based on formula 11 let us compute the increment in profit per one unit of production at the crop yield level of 20 and 21 centner/hectare, 40 and 41 centner/hectare, 60 and 61 centner/hectare.

An increase in the net profit from the sales of an additional centner of corn given an increase in the crop yield from 20 to 21 centner/hectare corresponds to a decrease in the cost of production and equals:

$$\Delta EBIT = \frac{4{,}992}{20^2 + 20} = 11.89 \text{ lei/center}$$

Analogously we obtain:

$$\Delta EBIT = \frac{4{,}992}{40^2 + 40} = 3.04 \text{ lei/center}$$

$$\Delta EBIT = \frac{4{,}992}{60^2 + 60} = 1.36 \text{ lei/center}$$

It is possible to observe that a higher economic effect can be achieved due to increases in the crop yield per 1 centner/hectare in the areas of low productivity. The Operating Profit line thus can be divided into three zones. Zone I is limited by the crop yield of 0-20 centner/hectare, zone II – by the crop yield of 20-40 centner/hectare, and zone III – by the crop yield of over 40 centner/hectare.

The first zone is characterized by high elasticity (high economic return) at an increase in the crop yield by 1 centner/hectare, the second zone – by moderate price elasticity, and the third zone – by low price elasticity respectively. Thus, agricultural enterprises in the zone of a low crop yield have substantial reserves for further growth in production efficiency. They can achieve a higher economic return per one lei of additional investment/costs compared to collective or husbandry farms with average or, moreover, high rates of crop yield.

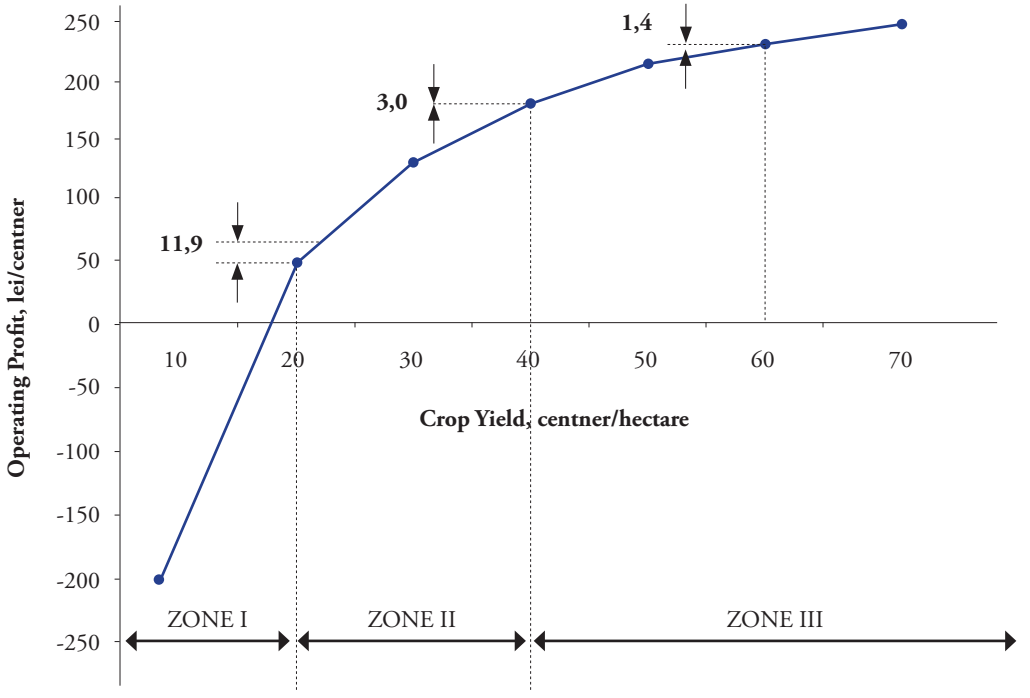

Figure 2. The Operating Profit-Crop Yield Relationship at Agro Sadim, LLC for FY 2011

Source: Agro Sadim, LLC Annual Report 2011, Form 7-APK and 9-APK

The level of the break-even price (pbe), below which the enterprise will have losses, is computed by the formula:

$$p_{be} = \frac{FC}{q} + AVC \tag{13}$$

This relationship can be obtained via conversion of Formula 5 of the break-even level of production and sales.

Agricultural enterprises have to be able to cover their cost of production by sales of produced and realized output as well as to have a certain economic surplus above the cost of production for accumulation of funds.

An absolute amount of net profit received by a collective or husbandry farm does not reflect the level of its profitability. Profitability is measured by the profitability index of agricultural production, the main index of economic efficiency of agricultural enterprises. In practice, profitability is determined only by the realized part of production through the comparison of revenues to production and sales costs.

For these purposes a relative measure – level of profitability (P) – is used. It stands for a percentage ratio of revenue to total costs of production and sales:

$$P = \frac{EBIT}{z} \cdot 100,\% \tag{14}$$

It is equally fair to assert the following equation of profitability:

$$P = \frac{R - z}{z} \cdot 100,\% \tag{15}$$

where R is the realized revenues in lei.

This formula determines profitability of specific agricultural products, production sectors, and collective or husbandry farms as a whole. It is important to consider that in the practice of economic computations three forms of the profitability index with a uniform economic meaning are used:

- level of profitability

$$P = \frac{EBIT}{z} \cdot 100,\%$$

- profitability

$$P = \frac{EBIT}{z}, lei / lei$$

- profitability index

$$P = \frac{EBIT}{z}$$

One of the measures that describe the efficiency of realized production output is sales profitability (P_{s}), which shows the gross or net profit per one lei of sales:

$$P_{sp} = \frac{EBIT}{R_{total}} \cdot 100,\% \qquad (16)$$

Today such measure as the rate of return on capital (r_{cap}) is also gaining wide popularity. It represents a ratio of total revenue (R) to total costs (z):

$$r_{cap} = \frac{R}{z} \qquad (17)$$

This index characterizes the amount of revenue per one unit of total costs. Production and sales of products are profitable only in case the value of the rate of return on capital is above 1.

Knowing the profitability index of realized production, it is easy to compute the profitability of sales and vice versa:

$$P_{sp} = \frac{P}{1+P} \qquad (18)$$

where P_{sp} and P are the profitability index of sales and the profitability index of realized production output accordingly.

$$P = \frac{P_{sp}}{1-P_{sp}} \qquad (19)$$

The rate of return on capital is:

$$r = 1 + P \tag{20}$$

$$r = \frac{1}{1 - P_{sp}} \tag{21}$$

In its turn:

$$P = r \ - 1 \tag{22}$$

$$P_{sp} = 1 - \frac{1}{r} \tag{23}$$

It is important to note that results of agricultural activities are largely influenced by soil fertility, air and soil temperature, level of precipitation, average number of sunny days per year and other natural conditions. The crop yield and the level of gross production increase in the years with favorable natural conditions and, accordingly, decrease in the years with unfavorable conditions. Therefore, depending on the quality of soil and weather, collective and husbandry farm enterprises achieve different levels of production output at otherwise equal material, labor and overhead costs. Keeping this in mind, analysis of production efficiency should be conducted with consideration of soil quality and within a long period of time – three to five or more years. It will allow to determine objectively the trends and development patterns and to smooth out moderately the effect of natural conditions on the level of production output.

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