TECHNICAL-ECONOMIC METHODS OF ANALYSIS AND OPTIMISATION OF ECONOMIC EFFICIENCY IN FORAGE CROPS

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Abstract: *Any agricultural activity aims at increasing economic efficiency and obtaining profit for the activity carried out. The geo-political, socio-economic and environmental context has diverging effects on agriculture. In Romania, grain maize occupies more than 30% of the cultivated area, alfalfa 4.5% and feed maize 0.6%. Given the importance of the livestock sector for food security, there is a risk, due to drought or other external factors, that farmers may not have enough feed for their animals and may therefore give up livestock farming. The study aims to provide a technical-economic basis for production costs and to compare the performance indicators of maize, feed maize and lucerne, economically important crops that would represent optimal solutions to ensure feed requirements in the livestock sector and contribute to "green and sustainable growth of economic activities".*

Key words*: costs, revenue, economic efficiency, green growth, sustainable growth*

INTRODUCTION

The aim of every entrepreneur in agriculture is to run a profitable business. This depends on the objectives they set themselves, the local context, supply and demand, i.e. the market, and not least on finding new income opportunities. In this context, growing silage maize is an opportunity for both the livestock sector and the small-scale farmer who owns arable land. The opportunity is provided by the National Strategic Plan 2023-2027 which provides income support for both silage maize (PD-26) and alfalfa (PD-10) [3]. "Reducing livestock below 50% of the agricultural share is an imbalance (even ecological) with dramatic economic and social consequences. The reduction of the compound feed industry and the resulting surplus of crops (cereals, poultry, grassland) which are no longer processed into animal products, poor nutrition, the reduction of animal protein consumption below the permitted limits all lead to a precarious public health situation, with serious implications for the biological and intellectual development of future generations" [5]. The livestock density per 100 hectares reflected a low utilisation of resources in the crop sector for all species and categories of animals and a significant gap with countries with developed agriculture providing a balanced food consumption of the population [13].

This study contributes to knowledge by highlighting the economic benefits of silage maize, alfalfa and grain maize, highlighting the link between cattle farming and the need to expand the area under these crops, highlighting the dependence of regions and counties on cattle farming and the cultivation of these three crops, and defining the role of these activities in rural employment.

MATERIALS AND METHODS

The data used to describe the correlation between livestock numbers and areas under grain maize, feed maize and lucerne are data from the National Institute of Statistics, Tempo online, for the 2007-2022 time horizon. Average indicator magnitudes were determined for the synthetic presentation of the data. "Most production processes in agriculture are subject to laws of non-linear variation, due to the non-proportional nature of the returns to the use of production factors" [7]. This characteristic of agricultural production gives it an optimisable character for most consumptions (use of fertilisers [2,9],

herbicides, fungicides, irrigation water, etc.) [2]. The production costing is based on technology estimates and income and expenditure budgets for grain maize, silage maize and alfalfa. The technology estimates were designed, for irrigated and non-irrigated production systems, using *the normative-constructive method* [1,6]. Revenue and expenditure budgets summarise and allocate technology expenditure into variable and fixed costs. The income indicator has been calculated in several variants: income without decoupled direct payments, income with decoupled direct payments and income with coupled support. The summary indicators that compare the economic results for maize, feed maize and lucerne are revenue, production costs, profit and profit rate [3,8]. Data are estimates for the production year 2023/2024.

RESEARCH RESULTS

In Romania, grain maize is grown, on average, on 30% of the arable area (2.4986 million hectares), silage maize is grown, on average, on 0.6% (46.142 thousand ha) and alfalfa on 4.5% of the arable area (369.741 thousand ha). For the period 2007-2022, the area under forage maize increased on average by 0.7915 thousand hectares/year, the area under lucerne increased by 8.6074 thousand hectares/year, while the number of cattle decreased on average by 49.4 thousand head/year. The moderate increase in the area under fodder maize can be explained by the fact that there was no demand for this crop, or some farmers gave up cattle rearing and did not continue to grow fodder maize, not finding opportunities to valorise the production. The peak periods for feed maize demand were in 2013, 2016, 2019, 2021 when areas exceeded 50 thousand hectares compared to the other years, this expansion can be associated with drought periods and demand for silage maize. Figure 1.

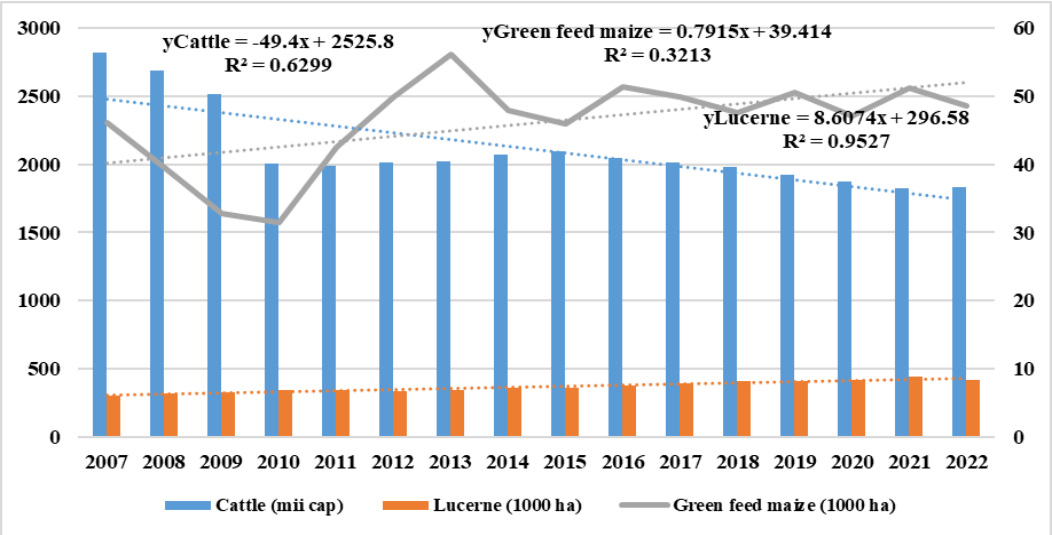


Figure 1. Evolution of cattle herds (thousand head) and areas under silage maize (thousand hectares) and alfalfa (thousand hectares)

In terms of areas under alfalfa, as of 2018, more than 400 thousand hectares are cultivated with alfalfa, the expansion of areas under alfalfa being driven both by the coupled support received by farmers and by its agronomic (nitrogen-fixing plant, drought resistance, improves soil fertility, etc.), economic (valuable source of cattle feed) and social (additional source of income) importance, etc.

Figure 2 shows the number of cattle returning per 100 hectares. Cattle breeding is an occupation present in every development region. Cattle rearing (predominantly in the North-East, North-West and Centre regions) is the main occupation for rural employment.

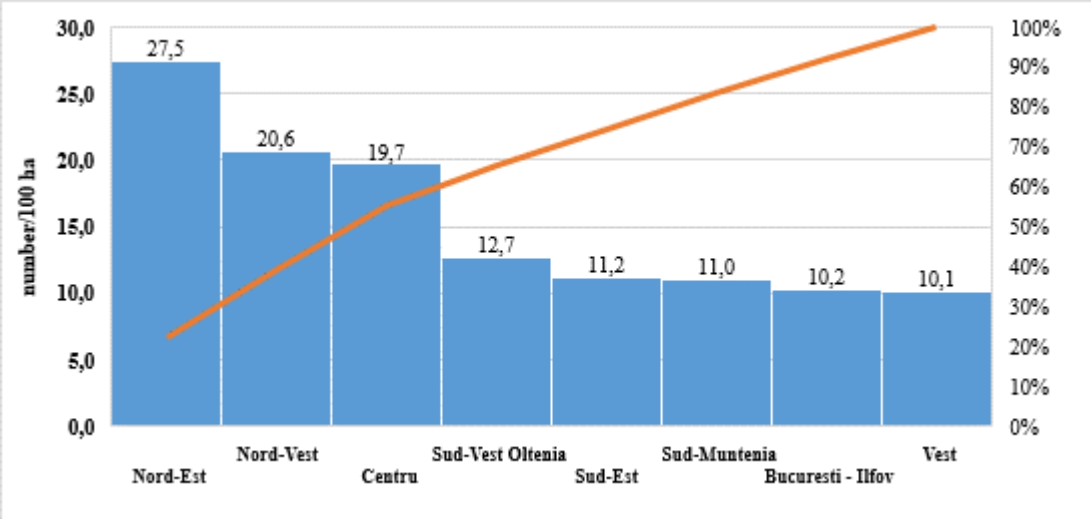
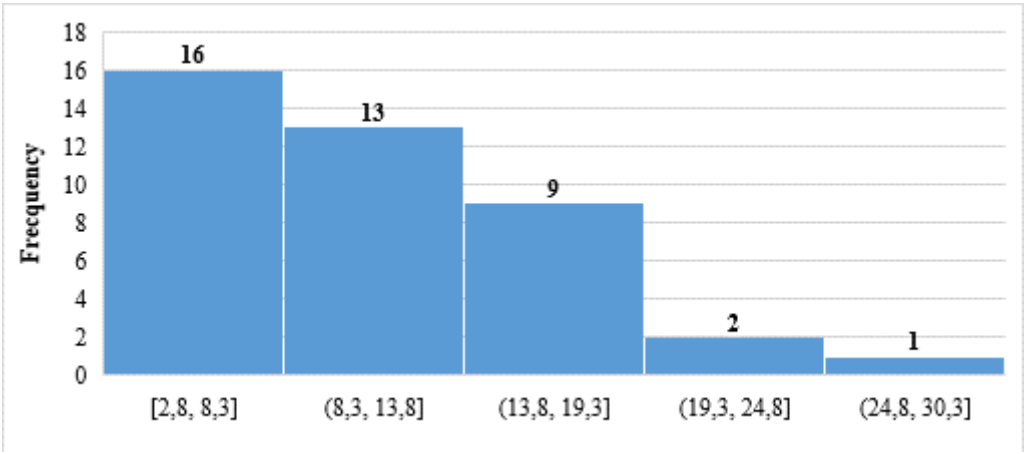


Figure 2. Animals returning per 100 ha of land, cattle category, by region at the end of the year

Source: National Institute of Statistics, Tempo data online

Histogram 1 groups counties into size classes according to frequency of occurrence.



Histogram 1. Grouping of counties in size classes according to herds of cows, buffaloes and heifers per 100 hectares, average 2007-2022 (number)

Source: National Institute of Statistics, Tempo data online

Frequency of occurrence of data in the range of minimum 2.8 cows, heifers and heifers/100 hectares to maximum 123.0 cows, heifers and heifers/100 hectares

Range from 24.8 heads to 30.3 heads/100 ha - 1 county: Suceava

Range from 19,3 heads to 24,8 heads/100 ha - 2 counties: Bistrita-Năsăud, Maramureș.

Range from 13.8 heads to 19.3 heads/100 ha - 9 counties: Neamt, Arges, Covasna, Botosani, Valcea, Vrancea, Harghita, Brasov, Cluj.

Range from 8.3 heads to 13.8 heads/100 ha - 13 counties: Mures, Alba, Iasi, Bacau, Gorj, Hunedoara, Satu Mare, Dâmbovița, Vaslui, Salaj, Sibiu, Prahova, Bihor.

Range from 2.8 heads to 8.3 heads/100 ha - 16 counties: Buzău, Mehedinți, Caraș-Severin, Olt, Brăila, Arad, Ilfov, Teleorman, Galați, Giurgiu, Dolj, Tulcea, Timiș, Ialomița, Constanța, Calarași.

Cow, buffalo and heifer farming is present in every county. In this context, farmers can buy their own fodder or, if they do not own animals, increase their income, and those near livestock farms would be the most advantaged if they produce and market their production directly to livestock farms, thus reducing some technological costs (labour costs, harvesting and transport costs, etc.) and thus practising the activity efficiently.

The economic efficiency category illustrates the useful effect or result achieved in relation to the expenditure of resources made in a given period. There are several approaches to the concept of economic efficiency: at the level of each economic agent, in the traditional approach, in the systems approach, in the cybernetic approach, etc., all of which symbolically reflect *the ratio of output to input or the ratio of effect to effort* [4]. In another approach, economic efficiency, expressed synthetically as the ratio of effect to effort, uses a series of financial, technical, social, etc. indicators for quantification [5].

Technological expenditure: Technological expenditure is broken down by category of work: mechanised work, manual work and materials. In terms of value, the categories of works are presented in absolute values (RON/ha) and in relative values (%), as well as in comparative analysis [11].

Expenditure on mechanised work: From the comparative analysis of direct production expenditure, for the three crops analysed, expenditure on mechanised work varies from 42.7% (for non-irrigated grain maize) to 57.9% (for non-irrigated alfalfa). Expenditure on mechanised work in non-irrigated maize is on average 6.4 percentage points higher than on mechanised work in irrigated maize.

Expenditure on manual labour - ranges from 1.5% (non-irrigated - silage maize) to 5.0% (alfalfa). Expenditure on manual work under non-irrigation is on average 4.3 percentage points lower than manual work under irrigation.

Expenditure on raw materials and materials varies according to the level of production of each crop and occupies shares of 51.0% (for silage maize - non-irrigated) and 61.7% (for grain maize - irrigated). Table 1.

Table 1.

Structure of technological expenditure

		Yield (kg/ha)	Technological expenses (lei), of which		Mechanized (%)		Manual (%)		Materials (%)	
			lei/ha	%	lei/ha	%	lei/ha	%	lei/ha	%
Grain maize	Non-irrigated	5445	5061	100	2160	42,7	100	2,0	2801	55,3
	Irigated	7622	6992	100	2245	32,1	436	6,2	4312	61,7
Maize silage	Non-irrigated	25715	6791	100	3223	47,5	103	1,5	3466	51,0
	Irigated	36001	8672	100	4205	48,5	410	4,7	4057	46,8
Lucerne green mass	Non-irrigated	15000	2661	100	1541	57,9	132	5,0	988	37,1
	Irigated	21000	3700	100	1790	48,4	392	10,6	1518	41,0

Source: Own calcualtion, production year 2023/2024

Total costs: Total production costs are broken down into variable and fixed cost categories. Variable costs for the crops analysed differ according to production purpose, production level and cropping system.

Variable costs: for non-irrigated variable costs range from 90% (alfalfa) to 93.1% for silage maize, and for irrigated variable costs range from 89% for grain maize and alfalfa to 90% for silage maize.

Fixed costs - are lower for non-irrigated (between 7.3% for grain maize and 10.0% for lucerne) and higher for irrigated, on average by 2.6 percentage points (Table 2).

Table 2.

Structure of production costs

		Yield (kg/ha)	Total expenditure, of which	Variable expenses		Fixed expenses		Unit production cost	
			lei/ha	lei/ha	%	lei/ha	%	lei/to	lei/kg
Grain maize	Non-irrigated	5445	5581	5174	92,7	407	7,3	1025	1,025
	Irrigated	7622	7685	6817	88,7	868	11,3	1008	1,008
Maize silage	Non-irrigated	25715	7481	6965	93,1	516	6,9	290	0,290
	Irrigated	36001	9679	8743	90,3	937	9,7	269	0,269
Lucerne green mass	Non-irrigated	15000	2917	2626	90,0	292	10,0	194	0,194
	Irrigated	21000	3518	3130	89,0	388	11,0	168	0,168

Source: Own calcualtion, production year 2023/2024

Grain maize - planned production ranges from 5,445 t/ha under non-irrigated to 7,622 t/ha under irrigated conditions. Estimated average yields range from 5990 lei/1207 euro to 8384 lei/1689 euro/ha. The average selling price taken into account was 1.100 lei/kg, the difference between price and cost being 0.075 bani/kg under non-irrigated and 0.092/kg under irrigated. The income without direct payments is 409 lei/82 euro, with a gross profit rate of 7.3%, for non-irrigated maize, and for irrigated maize the forecast gross income is 699 lei/141 euro, with a rate of 9.1%. In the variant without area payments, for every 1000 lei invested the farmer can obtain a gross profit of 73 lei for non-irrigated and 91 lei for irrigated. The income with direct payments is 1418 lei/286 euro for non-irrigated maize and 1709 lei/344 euro for irrigated maize, with corresponding profit rates of 25.4% and 22.2%, which means that for every 1000 lei spent, 254 lei and 222 lei respectively will go into the producer's profit. The share of decoupled direct payments in gross product is 14.4% for non-irrigated and 10.1% for irrigated. [10,11,12] (Table 3).

Table 3.

Result indicators for grain maize - production year 2023-2024

Indicators	UM	Non-irrigated		Irrigated	
		lei/ha	euro/ha	lei/ha	euro/ha
Average production	t/ha	5,445	5,445	7,622	7,622
Price of valorisation	u.m	1100	222	1100	222
Income/ha without any direct payment (rd. 1 x rd. 2)	u.m	5990	1207	8384	1689
Income/ha + area payments (rd. 3 + *)	u.m	6999	1410	9394	1892
Cost of production/ha	u.m	5581	1124	7685	1548
Profit without any area payment (rd. 3 - rd. 5)	u.m	409	82	699	141
Profit with area payments (rd. 4 - rd. 5)	u.m	1418	286	1709	344
Profit rate % (rd. 6/rd. 5) x 100)	u.m	7,3%		9,1%	
Profit rate % (rd. 7/rd. 5) x 100)	u.m	25,4%		22,2%	

Source: Own calcualtion, production year 2023/2024

*Direct decoupled payments = Basic Income Support for Sustainability (BISS) + Complementary Redistributive Support for Sustainability (CRISS) + Eco-scheme 04 Greening (PD-04) = 96.47 euro/ha + 50.61 euro/ha + 56.28 euro/ha = 203.360 euro/ha

1 EURO=4,9641 - Euro exchange rate on 30 October 2023 European Central Bank [16]

Silage maize - planned production ranges from 25,715 t/ha under non-irrigated to 36,001 t/ha under irrigated conditions. Estimated average yields range from 7715 lei/1554 euro to 10800 lei/2176 euro/ha. The average selling price taken into account was 0.30 lei/kg, the difference between price and cost being 0.009 bani/kg for non-irrigated and 0.031 bani/kg for irrigated.

The income without direct payments is 234 lei/47 euro, with a gross profit rate of 3.1%, for non-irrigated silage maize, and for irrigated maize the forecast gross income is 1121 lei/226 euro, with a rate of 11.6%. This means that for every 1000 lei invested the farmer can get a gross profit of 31 lei for non-irrigated and 116 lei for irrigated.

The income with area payments reaches 1243 lei/250 euro for non-irrigated silage maize and 2130 lei/429 euro for irrigated maize, with corresponding profit rates of 16.6% and 22.0%, which means that for every 1000 lei spent, 116 lei and 220 lei respectively will be returned to the producer's profit. For silage maize there is a third income option, provided by the coupled income support, PD-26, also granted by the NSP 2023-2027.

In the income + direct payments + coupled support variant, the profit rate reaches 31.9% or 33.8%, a variant that provides the producer with 319 lei or 338 lei for every 1000 lei invested in growing silage maize. The share of decoupled direct payments in the gross product is 21.8% for non-irrigated silage maize and 16.6% for irrigated silage maize. Table 4.

Table 4.

Result indicators for silage maize - production year 2023-2024

Indicators	UM	Non-irrigated		Irrigated	
		lei/ha	euro/ha	lei/ha	euro/ha
Average production	t/ha	25,715	25,715	36,001	36,001
Price of valorisation	u.m	300	60	300	60
Income/ha without any payment (rd. 1 x rd. 2)	u.m	7715	1554	10800	2176
Income/ha + decoupled direct pay. (rd. 3 + *)	u.m	8724	1757	11810	2379
Income/ha + decoupled direct pay. + PD-26 (rd 4 + **)	u.m	9866	1987	12952	2470
Production cost/ha	u.m	7481	1507	9679	1950
Profit without any pay. (rd. 3 - rd. 6)	u.m	234	47	1121	226
Profit with decoupled direct pay. (rd. 4 - rd. 6)	u.m	1243	250	2130	429
Profit with decoupled direct pay. + PD-26 (rd. 5 - rd. 6)	u.m	2385	480	3272	520
Profit rate (rd. 7/rd. 6) x 100)	u.m	3,1%		11,6%	
Profit rate (rd. 8/rd. 6) x 100)	u.m	16,6%		22,0%	
Profit rate (rd. 9/rd. 6) x 100)	u.m	31,9%		33,8%	

Source: Own calcualtion

*Direct decoupled payments = Basic Income Support for Sustainability (BISS) + Complementary Redistributive Support for Sustainability (CRISS) + Eco-scheme 04 Greening (PD-04) = 96.47 euro/ha + 50.61 euro/ha + 56.28 euro/ha = 203.360 euro/ha

**Coupled income support (PD-26) = 230 euro/ha

1 EURO=4,9641 - Euro exchange rate on 30 October 2023 European Central Bank [16]

Lucerne green mass - Planned production ranges from 15,000 t/ha (non-irrigated) to 21,000 t/ha under irrigated conditions. Estimated income from average yields ranges from 3150 lei/635 euro to 4410 lei/888 euro. The average selling price taken into account was 0.21 lei/kg, the difference between price and cost being 0.016 bani/kg for non-irrigated and 0.042 bani/kg for irrigated.

Income without decoupled direct payments: The income without direct payments is 233 lei/47 euro, with a gross profit rate of 8.0%, for non-irrigated alfalfa, and for irrigated alfalfa the forecast gross income is 892 lei/180 euro, with a rate of 25.4%. This means that for every 1000 lei invested the farmer can obtain a gross profit of 80 lei for non-irrigated and 254 lei for irrigated.

Income with decoupled direct payments The income with decoupled direct payments amounts to 1242 lei/250 euro for non-irrigated alfalfa and 1902 lei/383 euro for irrigated alfalfa, with corresponding profit rates of 42.6% and 54.1%, which means that for every 1000 lei spent, 426 lei and 541 lei respectively will go into the producer's profit. For

alfalfa and silage maize, there is a third income option, provided by the coupled income support, PD-10, also granted by the NSP 2023-2027.

Table 5.

Result indicators for alfalfa green mass - production year 2023-2024

Indicators	UM	Non-irrigated		Irrigated	
		lei/ha	euro/ha	lei/ha	euro/ha
Average production	t/ha	15,000	15,000	21,000	21,000
Price of valorisation	u.m	210	42	210	42
Income/ha without any payment (rd. 1 x rd. 2)	u.m	3150	635	4410	888
Income/ha + decoupled direct payments (rd. 3 + *)	u.m	4159	838	5419	1092
Income/ha + decoupled direct pay + PD-10 (rd. 4 + **)	u.m	4611	929	5871	1183
Cost of production/ha	u.m	2917	588	3518	709
Profit without any payment (rd. 3 - rd. 6)	u.m	233	47	892	180
Profit with decoupled direct payments (rd. 4 - rd. 6)	u.m	1242	250	1902	383
Profit with decoupled direct pay + PD-10 (rd. 5 - rd. 6)	u.m	1693	341	2353	474
Profit rate (rd. 7/rd. 6) x 100)	u.m	8,0%		25,4%	
Profit rate (rd. 8/rd. 6) x 100)	u.m	42,6%		54,1%	
Profit rate (rd. 9/rd. 6) x 100)	u.m	58,0%		66,9%	

Source: Own calcualtion

*Direct decoupled payments = Basic Income Support for Sustainability (BISS) + Complementary Redistributive Support for Sustainability (CRISS) + Eco-scheme 04 Greening (PD-04) = 96.47 euro/ha + 50.61 euro/ha + 56.28 euro/ha = 203.360 euro/ha

**Coupled income support (PD-10) = 90,9 euro/ha

1 EURO=4.9641 - Euro exchange rate on 30 October 2023 European Central Bank [16]

In *the income + direct payments + coupled support* variant, the profit rate reaches 58.0% or 66.9%, a variant that provides the producer with 580 lei or 669 lei for every 1000 lei invested in growing alfalfa. The total share of decoupled direct payments in gross product is 27.3% for non-irrigated lucerne and 21.1% for irrigated Lucerne (Table 5).

CONCLUSIONS

A comparison of income and expenditure indicators shows that none of the crops has a loss of income, but the degree of profitability is different. Grain maize can be harvested as silage maize, but not the other way round.

Farmers' incomes may increase if demand from livestock farms increases. In this context, farmers can improve their activity by making appropriate adjustments to production costs (reduction of material consumption, labour consumption, purchase of services, etc.) leading to cost reductions.

Cattle breeding (ruminant animals) is found throughout the country, in every county of the country, mainly in the North-East, North-West and Centre regions. In this context, cattle breeding is the basic occupation for the rural population.

Financial support to farmers for the expansion of alfalfa and silage maize areas contributes both to *green growth* and *to the development of a resilient, sustainable and competitive agricultural sector that will contribute to the development of sustainable agriculture.* [15].

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