

## Improving the Economics of Greek Agricultural Holdings: The Case of Asparagus Farming

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**Abstract:** The need to improve the competitiveness of Greek agricultural holdings necessitates a restructuring of crops and the promotion of crops with a commercial demand, which achieve a higher financial gain. Asparagus constitutes a financially profitable crop, since the total production is exported to European markets, primarily the German market. The aim of the present study is to examine the contribution of asparagus to the economicity of those agricultural holdings that include asparagus in their production plans. The study was conducted on a sample of asparagus-producing holdings in the Prefecture of Pella, with the use of Linear and Parametric Programming. The study showed that the gradual introduction of asparagus to the production plan of an agricultural holding results in a continuous increase of its gross profit. The contribution of asparagus to the formulation of the Total Gross Profit of the holding can range between 38.3%, when asparagus accounts for 25% of the cultivated area in an average holding, and even reach 54%, when the asparagus accounts for 40% of the area. When the asparagus is not included in the production plans of the average holding, the financial output of the holding is reduced by as much as 34%. However, a basic precondition for the planting of asparagus is to secure seasonal labourers for the months of April and May, which is the harvesting period for asparagus. The crops that can be included in the production plans alongside asparagus are freestone peaches, clingstone peaches, hard wheat and apples, kiwi fruit and industrial tomatoes.

**Key words:** asparagus, economicity, competitiveness, linear programming, parametric programming.

### INTRODUCTION

Within the framework of efforts to achieve increased competitiveness in agriculture, surplus reduction and the proper management of agricultural resources, the cultivation of asparagus presents a major interest, since it emerges as a dynamic practice, with the potential of distributing the product in the domestic and European market<sup>[18]</sup>.

Asparagus is a multi-annual crop, with a production lifespan of 13 years; its harvest begins in the 3<sup>rd</sup> year. In practice, some producers in Greece continue its cultivation even after the 13<sup>th</sup> year and up to the 15<sup>th</sup>, although it is believed in some European countries that its cultivation is financially profitable only until the 6<sup>th</sup> or 7<sup>th</sup> year of its life<sup>[12]</sup>.

The cultivation of asparagus began in Greece in 1961, with 2 ha in the region of Giannitsa, in Pella Prefecture; by 2005 it had spread to several regions all over the country, covering an area of 4,650 ha, with a production of 24,300,000 kg. Greece holds the 9<sup>th</sup> position on the global map for asparagus production, and the 4<sup>th</sup> position in Europe, accounting for 11% of the total European production<sup>[5]</sup>.

The rapid expansion of its cultivation is mainly due to its very encouraging financial results and the interest shown by farmers in introducing new crops into their agricultural holdings that involve products whose distribution will be problem-free. This is definitely the case for asparagus, since almost the total amount of produced asparagus is exported to the markets of Europe, primarily to Germany<sup>[18]</sup>. In recent years, Greek asparagus has accounted for 1/3 of the asparagus imported by Germany, and the value of the relevant exports amounts to 30,954,342 euros<sup>[4]</sup>.

The Prefecture of Pella is the key region for the development of asparagus cultivation in Greece, and accounts for 38% of the total cultivated area; the production of Pella Prefecture represents 88% approximately of the total production of Macedonia and 78% approximately of the total domestic production<sup>[15]</sup>.

The need to improve the competitiveness of Greek agriculture, in combination with the restructuring of crops and the expansion of crops with a commercial demand, which achieve a high profit, has created a demand for further research and programming that will help in making the right decisions and attaining a correct positioning of these crops within the framework

of the individual holding, and in the general policy of agricultural production as a whole.

The aim of the present study is to initially examine the contribution of asparagus farming to the economicity of asparagus-producing holdings, through an analysis of the existing production plans in the area of study. Then, the objective is to identify the optimum combination of those production sectors that frame the basic cultivation of asparagus, in order to better arrange and exploit the production coefficients that the farmer has at his disposal, and improve the financial output through the use of programming methods, such as Linear and Parametric Programming.

### MATERIALS AND METHODS

In order to conduct the research a sample of 35 asparagus -producing holdings were selected from the Prefecture of Pella. In this Prefecture, asparagus co-exists with the cultivation of peaches, cotton, wheat, maize, tobacco, apples, kiwi fruit and cherries. The most important products of this prefecture, as regards their contribution to the formulation of the gross revenue from farming, are: peaches, tobacco, cotton and asparagus, followed by cherries, apples and greenhouse crops<sup>[15]</sup>.

This region presents a dynamic agricultural activity, as well as significant activity in asparagus farming; it is considered that the variety of cultivating conditions present in these regions allows for a generalization of the study's results for the whole country, without constituting a major deviation from the real picture.

The sample was selected using careful sampling, as it was considered necessary to work with producers who were willing to provide reliable technical-economic data over a long period, since the quality and accuracy of the provided information are of utmost importance in this type of study<sup>[3,7]</sup>.

From the sample of agricultural holdings in the Prefecture, descriptive and diagnostic information was collected using accounting monitoring on an annual basis for the year 2005.

The descriptive information provides a picture of the existing situation at the average agricultural holding and refers both to the quantity and quality of the production coefficients available, and to the technical data (crop yield, their requirements of resources). More analytically, data was collected concerning:

- The production sectors that are included in the production plan of the agricultural holding.
- The quality (dry or irrigated) and origin of the land (privately-owned or leased) in order to define whether the land at the agricultural holding is suitable for the cultivation of asparagus and to determine its cost of use.
- The composition of the agricultural family, the educational level of its members and their participation in the agricultural work at the holding, thus defining the

available family labour at the holding. The family labour used at the holding, measured in Human Labour Units (IHLU=1, 750 hours).

- The demands of the production sectors in human and mechanical labour, and in consumables (seeds, drugs, fertilizers, fuel etc).
- The yield achieved by each farm enterprise.

From a processing of the descriptive information, we arrive at the diagnostic information (gross profit, variable cost etc), that is used to define and analyze the problem and then act in order to achieve the relevant objective. This data is also used to strengthen the strong points of the agricultural holding, i.e. they give the producer the opportunity to take advantage of the opportunities that exist at the holding<sup>[13]</sup>. In the present study, the diagnostic information used was variable cost, gross income and gross profit, calculated for each production sector of the agricultural holding. Following this, the maximization of the financial output of the agricultural holdings is achieved by selecting those farm enterprises that provide the highest yield per unit of constrained resource; since they produce the highest yield for those coefficients, it is obvious that they will also produce the highest yield for all the production coefficients<sup>[10]</sup>. Useful tools for the maximization of the financial output of the agricultural holding, by selecting the optimum production plan, are the methods of Linear and Parametric Programming. Linear Programming has been established in the field of agricultural economy as the tool for analyzing problems related to the management of agricultural holdings, with the aim of helping farmers to achieve the highest possible income or the lowest cost, through a better use of the existing resources. Several researchers have applied the Linear Programming technique to problems related to the organization of agricultural holdings, such as Heady & Eggest<sup>[16,14,1,9,2,16,10,21,20,8,17,18,19]</sup> and others. The mathematical formula for Linear Programming is the following:

$$\text{Max } Z = \sum_{j=1}^n c_j x_j + \sum_{j=1}^n (-c_j x_j) \quad (1)$$

when

$$\sum_{j=1}^n a_{ij} x_j \leq b_i \quad (2)$$

$$x_j \geq 0 \quad (3)$$

$i$  = production coefficients (  $i = 1, \dots, m$  )

$j$  = production sectors (  $j = 1, \dots, n$  )

- $x_j$  : the level of productive activity  $j$  at the holding.
- $c_j$  : the gross profit per unit of the productive activity  $j$ .
- $a_{ij}$  : the quantity of the coefficient  $i$  required for the production of one unit of the productive activity  $j$ .
- $b_i$  : the available quantity of the coefficient  $i$ .

We consider  $c_j$  and  $a_{ij}$  to be stable, regardless of the level of productive activity  $j$ . The objective function (which expresses what is "desirable") in this particular case, maximizes the total Gross Profit of the holding. The Gross Profit of a production sector is calculated as the difference of the Variable Cost of the sector to the Gross Revenue<sup>[11]</sup>. The Gross Profit of each sector appears on the matrix with a positive sign below each activity. However, when the activity represents payment for an external production coefficient (e.g. leasing of land, hired labour) then its cost appears in the objective function with a negative sign. Parametric Programming is a method used for analysis after the initial optimum solution of Linear Programming. This method allows someone to consider the impact of a sequence of incremental changes in any of the model coefficients. The matrix for Parametric Programming is the same as that for Linear Programming; the only difference is the fact that in the former it is possible for each of the technical-economic coefficients ( $c_j$ ,  $a_{ij}$ ,  $b_i$ ) to change, thus providing a series of optimum plans<sup>[11]</sup>. It is worth noting that the Parametric Programming method presents better results when it is applied to the average holding (modal farm), where the solutions of Linear Programming are used to provide the guidelines for organizing production, to a number of farmers whose resource levels, e.g. land area, will obviously differ<sup>[10]</sup>. In the present study, the constrained resources are the land, the hours of human labour per month and the variable capital of the agricultural holding. In the restrictions to the production sectors, as regards the area they can cover, the existing production plan of the region has been taken into account, along with the implemented crop rotation and the possibilities of expanding certain crops and reducing others. Finally, although the cultivation of asparagus, peaches (freestone and clingstone), apples, nectarines and kiwi fruit are multi-annual crops, for the application of the programming methods they were used as annual crops, in an effort to present the dynamic nature of these crops and their possibilities for expansion. Their demands regarding technical-economic coefficients were calculated according to their average lifespan.

## RESULTS AND DISCUSSION

**Results:** From the analysis of the descriptive and diagnostic information provided by the 35 asparagus-producing holdings in the Pella Prefecture for the year 2005, the following conclusions were reached:

The average agricultural holding in the Pella Prefecture includes 5.2 ha of privately-owned irrigated land; the available family labour is estimated at 4,425 hours (2.5 HLU). As shown in Table 1, the majority of the human labour is distributed over the summer months of June, July and August, and estimated at 490 hours

per month, with a reduction for the winter months of November, December and January, when it is estimated at 225 hours per month.

In the existing production plan of the average holding in the prefecture, the cultivation of asparagus accounts for 28.8% of the total cultivated area, cotton for 27%, freestone peaches for 19.2%, nectarines for 11.5%, clingstone peaches and hard wheat for 3.8%, while industrial tomatoes, apples and kiwi fruit account for 1.9% of the total area of the holding (Table 2).

The composition of the production sectors in the existing plan makes use of 3,224 hours, of which 699 hours (21.7%) correspond to external seasonal labour. The need to employ seasonal labourers is present in the months of April, May and August, when the level of employment per month is estimated as being 135.6%, 156% and 177.7% respectively (Table 3).

The cultivation of asparagus seems to claim the biggest percentage (37.7%) of the required human labour according to the production plan, followed by the freestone peaches at 24.3%, cotton at 15.5%, nectarines at 9.4%, clingstone peaches at 4.7%, kiwi fruit at 3.1% and apples and industrial tomato at 2.7% and 2.5% respectively.

Finally, the Gross Profit achieved amounts to 26,18 euros (5,119 euros/ha) and is mainly formulated by the cultivation of asparagus, which contributes at a level of 50.7% (Table 2).

In the first effort to study the combination that will frame the cultivation of asparagus and take advantage of the available production coefficients in the best possible way, an attempt was made to optimize the existing situation by only using the man hours available at the holding, i.e. 2.5 HLU (Table 4).

Following the application of Linear Programming, it emerged that the available amount of labour did not suffice to adequately exploit an area of 5.2ha, thus resulting in a low Gross Profit. The sectors that can be covered by the available labour are asparagus (1.1ha), clingstone peaches (0.3ha), freestone peaches (0.8ha), apples (0.5ha), hard wheat (0.5ha) and kiwi fruit (0.2ha) (Table 4).

This first observation led us to examine the problem that is related to the available labour for the months of April, May and August. The farmer's decision to cultivate 5.2ha, and at least 1.5 of these with asparagus, as we can see in the existing production plan, is based on the use of seasonal labourers during the months of April, May and August, corresponding to 26.3%, 38.7% and 36% of the total labour requirements for these three months. Asparagus presents increased human labour requirements during the months of April and May, when the crop is harvested. Industrial tomatoes present an increase in human labour demands during the months of May and August, and in the same months, we have increased labour requirements for both crops of freestone and clingstone peaches.

**Table 1:** Total and monthly available family labour at the average agricultural holding in the Pella Prefecture.

onths	J		F		J		J		S		D		Year's Total
	hrs	hrs	hrs	hrs	hrs	Hrs	hrs	Hrs	hrs	hrs	hrs	hrs	
Available labour	225	240	357,5	392,5	450	490	490	490	450	340	250	250	4,425

Source: Processing of sample data

**Table 2:** Existing production plan of the average holding for the year 2005.

Production Sectors	Area (ha)
Asparagus	1.5
Mech/ly harvested cotton	1.4
Hard wheat	0.2
Industrial tomato	0.1
Apples	0.1
Nectarines	0.6
Freestone peaches	1
Clingstone peaches	0.2
Kiwi fruit	0.1
Total Area	5.2
Gross Profit (euros)	26,618
	(5,119euros/ha)

Source: Processing of sample data.

In accordance with the above, tests are made in relation to the amount of external labour required, in order to arrive at the optimum production plan that will exploit the area of 5.2 ha in the best possible way (application of Parametric Programming).

The available family labour was initially reinforced with 112 days (900 hrs) of hired labour distributed over the months of April, May and August, and involving all farm enterprises (Table 4). As a result, only 90% of the cultivated area is exploited, and the asparagus-producing area is increased to 2.1ha. The crops cultivated alongside the asparagus are clingstone peaches, whose area is reduced to 0.15ha, freestone peaches that

**Table 3:** Requirements of the existing production plan in human hours

onths	J		F		J		J		S		D		Total no of cultivation hours
	hrs	Hrs	Hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	
<i>Production sectors</i>	hrs	Hrs	Hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	hrs	
Asparagus (mean)	0	18	210	442.5	343.5	54	88,5	60	0	0	0	0	1,216.5
H.Wheat	0	1.2	0.4	0.2	0	0.8	0	0	0	1.4	2	0	6
Industrial tomato	0	0	0.5	0.8	20.6	4	2.2	51.7	0	0	0	0.3	80.1
Cotton	0	8.4	2.8	61.6	63	93.8	96.6	61.6	15.4	53.2	42	0	498.4
Apples	0.1	13.7	13.4	10.6	1.2	1.1	16.4	0.6	30	0	0.5	0	87.6
Nectarines	0	63.8	1.8	4.2	90	4.2	29.4	106.2	1.2	0	1.2	0	301.9
Freestone peaches	80	39.1	3	10	188	29	35	394	3	0	2	0	783.1
Clingstone peaches	12	11.1	0.6	1.2	25	1.2	11	87.8	0	0	0.4	0	150.3
Kiwi fruit	0	20.7	0.2	1.2	2.7	14	10.7	3	47.7	0	0	0	100.17
Total hours	92.1	175.9	232.7	532.3	734	202.1	289.8	764.9	97.3	54.6	48.1	0.3	3,224.1
Hired labour				139.8	284			274.9					698.7

Source: Processing of sample data

are increased to 1.2ha, and apples, hard wheat, and kiwi fruit that maintain the same area; at the same time, the industrial tomato is also introduced into the production plan with 0.05ha.

The requirements of the production plan as regards human labour amount to 3,449 hours, 22% of which are covered by seasonal labourers. The dependence of the holding on external labour during the months of April, May and August, is estimated at 43%, 40% and 25% respectively. The cultivation of asparagus accounts for 49% of the total requirement for human labour.

What must be pointed out is the substantial increase to the Gross profit, that amounts to 35,111 euros (7,470 euros/ha), signifying an increase of 36% compared to

what is achieved by plan 1 and a 24% increase in relation to the existing production plan. The cultivation of asparagus contributes to the formulation of the Gross Profit by 54%.

The possibility of fully exploiting the available land at the average agricultural holding is related to securing the provision of additional external seasonal labour during the peak months. Thus, by securing 112 days

(900 hours) of external seasonal labour for each of the peak months, we come to plan 3 (Table 4), which involves a full exploitation of the 5.2ha of arable land. Securing additional labour for the months of May and August, allows for an expansion of the cultivation area

of industrial tomatoes to 1 ha, at the expense of clingstone peaches which are not included in the new production plan, of asparagus that is reduced to 2ha, and of freestone peaches and hard wheat, which are cultivated in 1.16ha and 0.34ha respectively. The apples and kiwi fruit maintain the same area with 0.5 ha and 0.2 ha respectively.

In the new plan, the requirements for human labour are estimated at 3,980 hours, and the dependence on external seasonal labour amounts to 33%. The month that is linked to the highest demand for human labour is August, when 54% of the demand is covered by external labour. The crop with the highest human labour requirements is asparagus, which accounts for 41% of the total demand for human labour in the production plan.

The new production plan increases the Gross profit of the average agricultural holding to 35,601 euros (6,846 euros/ha), which is 14% higher than plan 2 and 34% higher than the existing production plan. Asparagus contributes to the formulation of the Gross Profit by 51%.

Finally, within the framework of the effort to examine the financial contribution of asparagus farming to the holdings in the prefecture, the case of excluding asparagus from the production plan of the average holding was also investigated.

In this case, the Linear Programming method was applied with the same labour limitations that were set in plan 4. The new plan that emerged, only exploits 87% of the arable land and the absence of asparagus shrinks the Gross Profit of the holding to 23,462 euros (5,213 euros/ha). The demand for human labour is estimated at 3,136 hours and the dependence of the holding on external seasonal labour amounts to 23.3%, mainly centred on the months of May (24%) and August (65%) ( Table 4).

**Table. 4:** The production plans that emerged from the application of Linear and Parametric Programming.

Production Sectors	Plan 1	Plan 2	Plan 3	Plan 4
Area in ha				
Asparagus	1.1	2.1	2.0	
Clingstone peaches	0.3	0.15		0.74
Freestone peaches	0.8	1.2	1.2	1.2
Mech/ly harvested cotton				
Apples	0.5	0.5	0.5	0.5
Industrial tomato		0.05	1.0	1.0
Hard wheat	0.5	0.5	0.34	0.5
Nectarines				0.37
Kiwi fruit	0.2	0.2	0.2	0.2
<b>Total</b>	<b>3.4</b>	<b>4.7</b>	<b>5.2</b>	<b>4.5</b>
Gross Profit (euros)	25,845	35,111	35,601	23,462
Required labour (hrs)	2,397	3,449	3,980	3,136
External labour April (hrs)		296,	273	
External labour May (hrs)		297	443	141
External labour August (hrs)		26	573	899

**Conclusions and Proposals:** The need to improve the competitiveness of Greek agricultural holdings necessitates the restructuring of crops and the promotion of crops that offer a guaranteed distribution and high profit.

Asparagus constitutes a profitable financial crop, since the total production is exported to European markets, mainly the German market. The guaranteed promotion of the product and its high selling price have led to a rapid expansion of the crop in many regions of Greece.

The main focus and most important cultivating area at present for asparagus is the Prefecture of Pella. The cultivation of asparagus began in this prefecture with 2 ha in 1961 and reached 1,780ha in 2005, thus accounting for 38% of the total cultivated area with asparagus in Greece, and 78% approximately of the overall domestic production.

The significance of asparagus cultivation at the level of the agricultural holding was examined in the present paper using the Linear and Parametric Programming methods.

From an analysis of the data collected from a sample of 35 asparagus-producing holdings in the Prefecture of Pella, the following observations were made:

The size of the average holding in the prefecture is 5.2 ha and represents 2.5 HLUs. The area for asparagus ranges between 1.5 and 2.1ha, depending on the availability of external seasonal labour for the months of April and May, when the asparagus is harvested. The gradual introduction of asparagus into the production plan of the average holding results in a continuous increase to its Gross Profit. The contribution of asparagus to the formulation of the Total Gross Profit for the holding ranges from 38.3%, when asparagus covers 25% of the area in the average holding, to 54%, when asparagus covers 40% of the holding's cultivated area.

When the asparagus is not included in the production plans of the average holding, the financial output of the holding is reduced by up to 34%.

The crops that are included in the production plans with the asparagus are freestone peaches that can cover up to 1.2ha, clingstone peaches with up to 0.3ha, hard wheat and apples with up to 0.5ha each, kiwi fruit with up to 0.2ha and industrial tomatoes with a maximum area of 1ha.

The introduction and expansion of the industrial tomato crop in the optimum production plans depends on securing a high level of external labour for the months of May, the peak month for asparagus, and August, the peak month for the cultivation of freestone and clingstone peaches.

As we can observe in the present study, the introduction of asparagus farming within the framework of an agricultural holding leads to an increase of its financial output and improves its competitiveness. This fact necessitates the promotion of its cultivation through information campaigns for farmers, regarding the

financial prospects of asparagus farming, and the requirements for its cultivation. Since asparagus is also a product with a major distribution potential in the domestic and European market, the terms and conditions

for its trade need to be improved. The setting up of a strong advertising campaign in selected markets in Europe and in Greece, along with the establishment of long-term collaborations with supermarket chains would lead to a better planning of the production and commercial process.

Finally, the creation of a professional flexible management body for asparagus, with the participation of all those involved in the production and trade of the product (producers, traders, academics, research centres etc.) could assist in an improved organization of its production and trade processes.

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