

LEGAL-ECONOMIC ANALYSIS OF THE MANAGEMENT OF HARVEST RESIDUES IN SOUTH-EAST EUROPE

Commission III – Significant current developments in Rural Law

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I. THE STRATEGIC LINES OF THE PAC AND THE CROP RESIDUES.

1.1 Southeast Europe: Almeria.

The economic study on the remains of the harvest will focus on Almeria, located in Southeast Europe, because it is the place with the highest concentration of greenhouses in Europe; and because here the horticultural sector continues to demonstrate its strength and its value is strategic for the national and Andalusian economy, both for its contribution to final agricultural production and for its clear vocation to export, mainly to Europe which provides fruit and vegetables in a sustainable way under the innovation and development of a sector that needs specific regulation on the use and management of the remains of the harvest, like so many others.

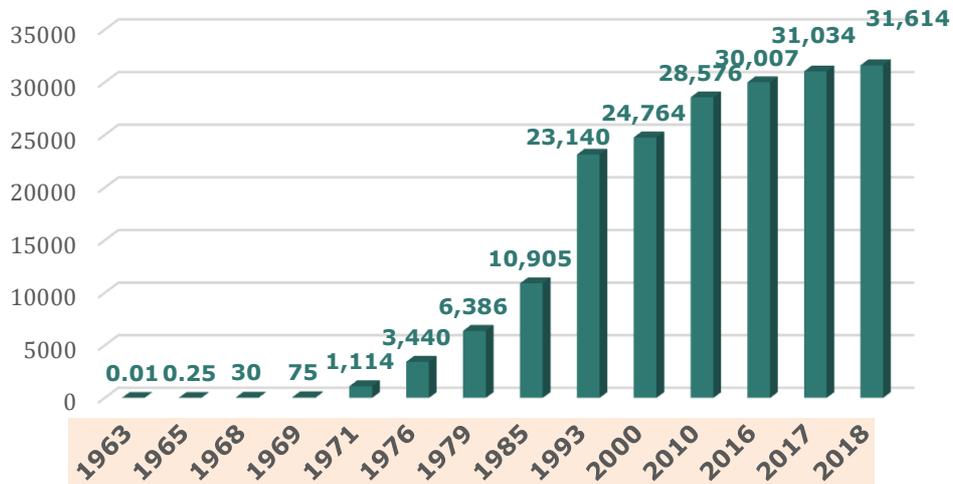
In surface data, the Ministry of Agriculture, Fisheries and Rural Development of the Junta de Andalucía confirms that Almería concentrates 87.4% of greenhouse facilities in Eastern Andalusia with a total of 31.614 hectares (representing 58.9% of Europe's wintering area¹), thus monopolising the increase in the entire Mediterranean strip by registering 580 hectares more than in 2017, all this, with the regions of Almeria's Poniente (21,545 hectares, 260 more) and Campo de Níjar and Bajo Andarax (8,748 hectares, 280 more than in the previous year) as the main bastions. The map of crops under Almeria's plastics is completed by the areas of Bajo Almanzora (686 hectares), Campo de Tabernas (326 hectares), Río Nacimiento (243 hectares) and Alto Andarax (66 hectares).

These surface data are translated into tons of production and harvest residues as we will see below, which when they leave the greenhouse are classified as residues with the presence of pesticides². This source of contamination of the environment by pesticides is very important given the large amount of plant residues generated in greenhouse crops in Almeria.

¹ <https://www.publicacionescajamar.es/pdf/publicaciones-periodicas/mediterraneo-economico/2/2-15.pdf>

² Endosulfan was the most frequently detected pesticide (in 33 of the 45 samples), so there is an urgent need to control these post-harvest remains, particularly if they are used as livestock feed (Garrido-Frenich, 2003; Martínez-Vidal, et al. 2004b).

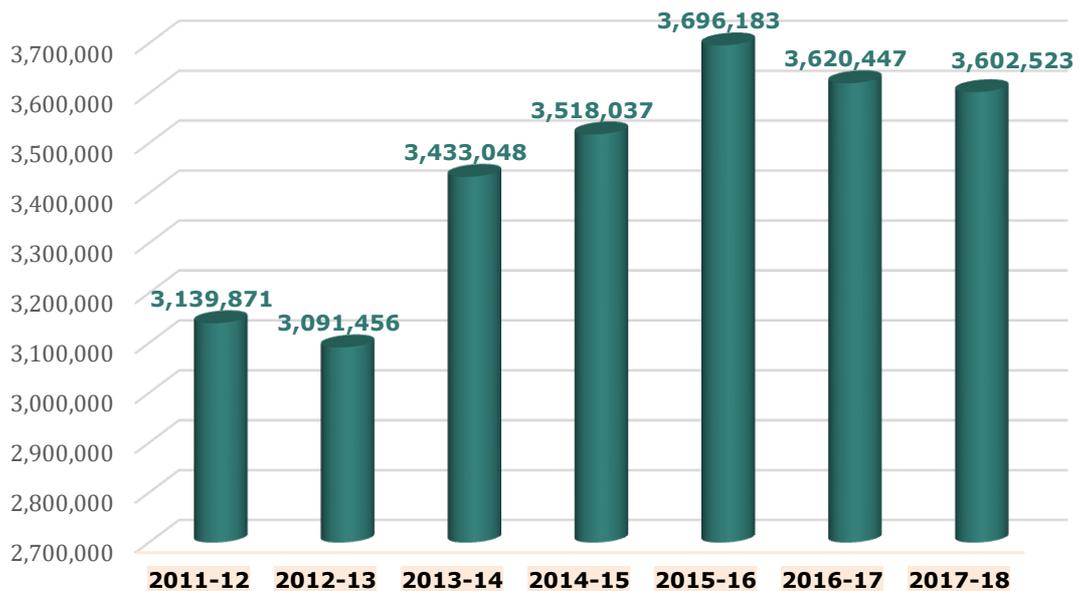
FIGURE 1. Evolution of the surface of greenhouses in Almería (hectares).



Source: Prepared by the authors based on data from Hortoinfo and the Ministry of Agriculture, Fisheries and Rural Development of the Regional Government of Andalusia.

This area yields production data of more than 3.5 million tonnes since the 2014/15 seasons in Almería, although in the last 7 years have not fallen from the 3 million tonnes of green plant debris.

FIGURE 2. Evolution of Almería Horticultural Production (Tm)

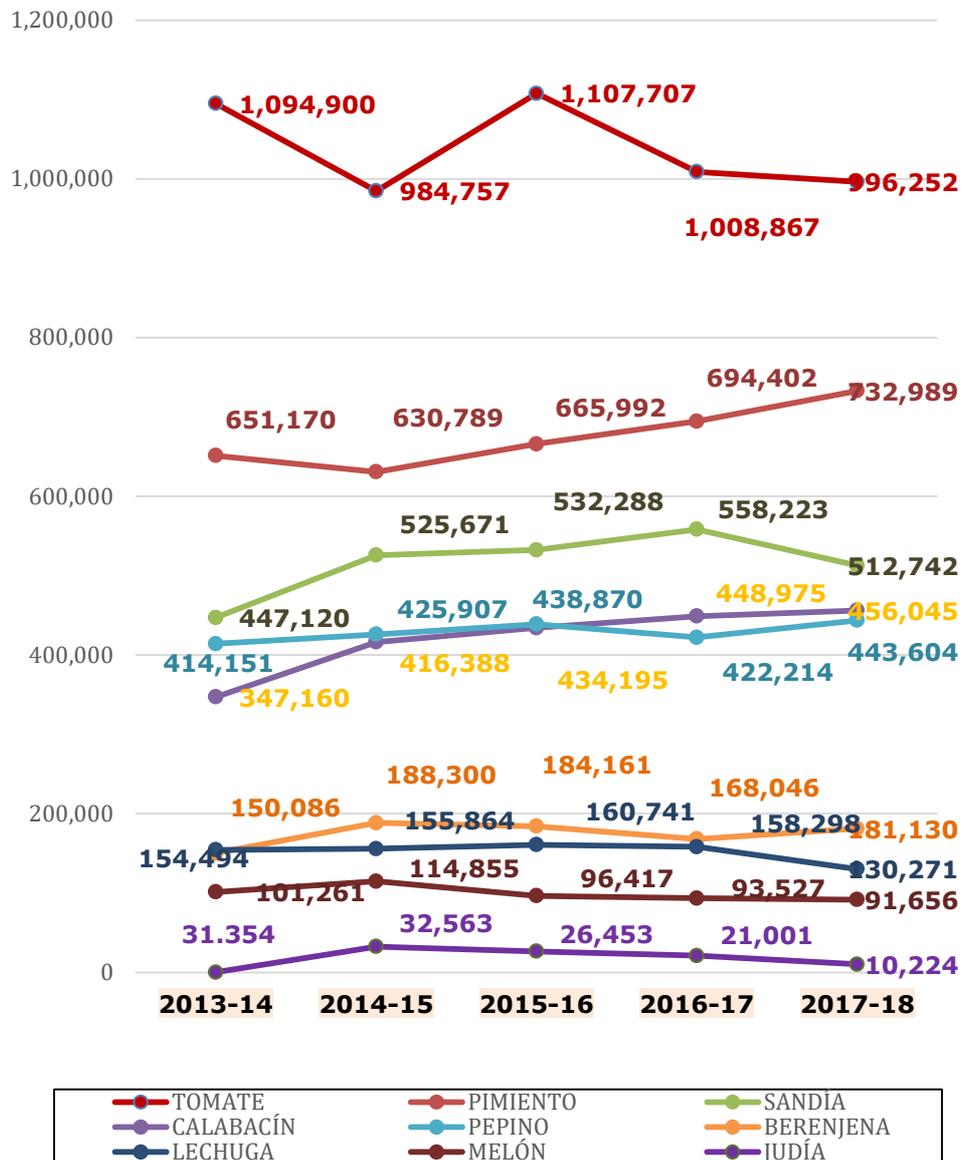


Source: Own elaboration based on data from the Ministry of Agriculture, Fisheries and Rural Development of the Junta de Andalucía.

The production systems that we find under plastic in Almeria are diverse, and serve two cycles per annual campaign, autumn and spring, which focus on tomato, pepper, courgette, cucumber, eggplant, lettuce, watermelon, melon and bean. Species for which we provide production data so that we can have an idea of the tonnes produced in south-east Europe, and whose purpose once withdrawn is diverse, as is their economic value.

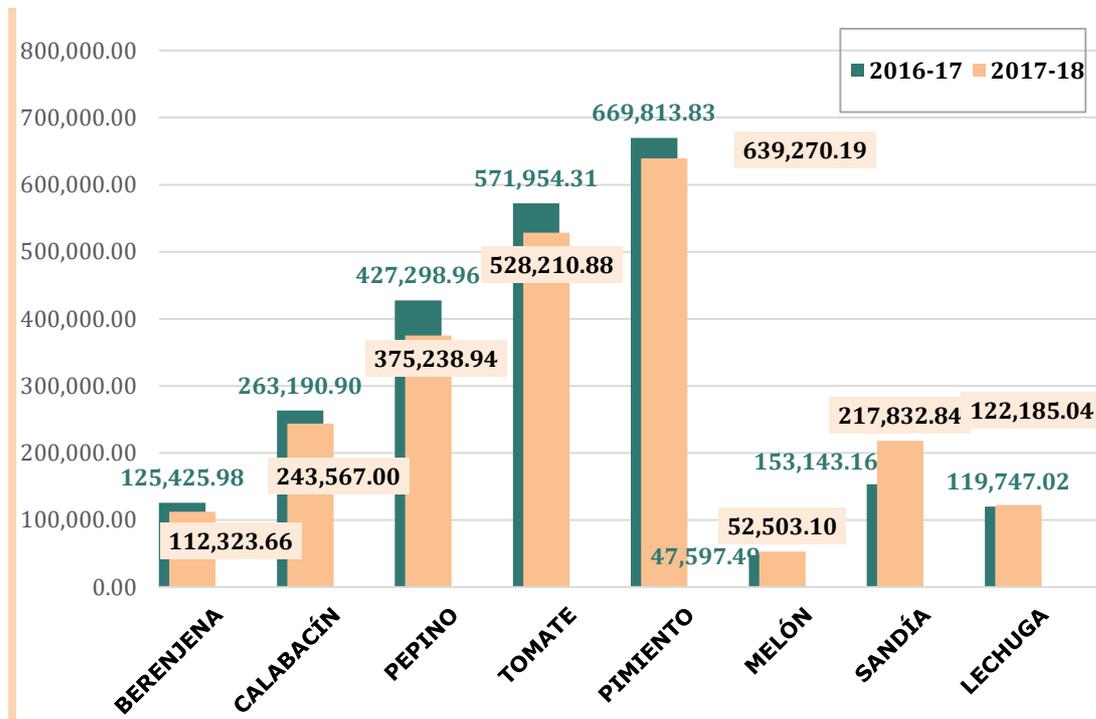
However, in order to regulate the use and management of plant remains in terms of economic profitability, these data must be centred on the harvest residues generated per cultivated product, as it is not the same vegetable mass that remains in a production of cabbages, which is obtained from a tomato production at the end of the season, whose biomass is lower. But not only for the amount of organic matter, but also with respect to its use for the soil, because while the remains of cabbage allow us to disinfect the soil, those of the tomato will need other external inputs of plant remains, organic fertilizers or even chemical elements depending on the type of soil disinfection or other uses to which we want to destine them.

FIGURE 3. Evolution of Almeria Horticultural Production by Products (Tm)



Source: Own preparation based on data from the Ministry of Agriculture, Fisheries and Rural Development of the Junta de Andalucía.

FIGURE 4. Evolution of the value of exports from Almeria by product (thousands of euros).



Source: Own preparation based on data from the Ministry of Agriculture, Fisheries and Rural Development of the Regional Government of Andalusia.

All these figures highlight the enviable excellence in the sector that opens the doors to our vegetables in international markets as well as the professionalization of the sector, both for the part that corresponds to the production and that on which the marketing is based. On the other hand, we have to take into account the change that has taken place in the companies around the farmer, who not only sell him inputs in order to be able to carry out his production work, but also are the ones who are researching to bring added value to the work in the greenhouse and contribute to the fact that the horticulturist's own profit and loss account gives positive dividends each season from respect for the environment and bringing life through food to the consumer.

However, these data and those that specifically appear in the following section (1.3) show as weaknesses the high seasonal concentration in two seasons of the year of plant remains that the producers of Almeria consider should be managed in order to be more efficient and productive, through greater energy efficiency and the use of water, advances, innovation, technology and modernization of structures, the management of the remains of harvest and the increase in organic production that continues to keep us on the path of sustainable growth, always bearing in mind the consumer as a reference center in our innovations related to environmental sustainability and the quality demanded in our markets by who is the final buyer of our products.

1.2 STRATEGIC LINES OF THE PAC.

The current situation of intensive agriculture in south-east Europe, which is mainly dedicated to greenhouse horticulture production, implies the lifting and withdrawal of the crop on two occasions, at the end of the autumn cycle, between January and February, up to and including March and the end of the spring cycle in May and June, with the consequent economic cost.

TABLE 1. Cost of removal and external management of greenhouse plant remains.

PARTIDAS	COSTE (€/M ²)
Retirada de invernadero	0,012
Transporte a planta	0,012
Gestión de planta	0,075
TOTAL	0,099

Source: Agronomic use of plant remains in greenhouse, 2014. (Torres Nieto, J.M.). Costs are quantified for the plant remains of a tomato crop.

Both cultivation cycles lead to the generation of a large volume of plant remains, some of which have been described by some as a management problem in areas³ such as southeast Spain, where there is a high concentration of intensive cultivation under plastic, and which we are going to try to demonstrate can become an opportunity for the farmer and an environmental advantage, both in line with the new Strategic Plan of the CAP.

In this respect, we must bear in mind that the monitoring and evaluation of the common agricultural policy requires comparable, up-to-date and reliable information on the economic situation of the agricultural sector⁴ and, more specifically, on the evolution of agricultural income. There are three general objectives for developing the measures in the Strategic Plans of the new CAP (period 2021-2027)⁵:

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- b) Strengthen environ
- c) Strengthen the so

Thus, the general objective of this work will be to point out the deficiencies and loopholes with legal arguments that will be supported by economic data, under the methodology of economic analysis of the law; since in the present and future, the CAP is giving priority to the implementation of a more sustainable management of the food complex, for which it is essential to improve the management of plant remains of

³ Rivera, J.: "Conclusiones del encuentro medioambiental almeriense". Universidad de Almería y Servicio de publicaciones de Caja Rural de Almería. Almería. 1999. For Riviera it constitutes an environmental and economic problem in the productive zones of Almeria. In the same sense Tores Niet speaks. Vid. TORRES NIET, J.M.: "Uso agronómico de restos de cosecha en los invernaderos enarenados de la cuenca mediterránea". Julio. 2016.

⁴ Economic accounts for agriculture are drawn up in accordance with the basic concepts and rules of Council Regulation (EC) No 2223/96 (LCEur\1996\3829) of 25 June 1996 on the European system of national and regional accounts in the Community. Regulation as last amended by Regulation (EC) No 1267/2003 (LCEur\2003\2145) of the European Parliament and of the Council (OJ L 180, 18.7.2003, p. 1).

⁵ On 1st June 2018 the European Commission presented its legislative proposals on the future of the CAP after 2020 (period 2021-2027). These legislative proposals aim to adapt the new CAP to the future and are condensed into 3 regulations: on the Strategic Plans of the CAP; on the single Common Market Organisation (CMO); and on the financing, management and monitoring of the CAP. We detail each of them to inform you in detail.

protected crops under the perspective of the circular economy, responding to the specific problems currently presented by its management in the absence of regulation, which are well known by the sector and have been contrasted by the CAPDR and all stakeholders, through a set of measures that are financed with the specific support instruments currently available⁶.

1.3 INDEXES OF VEGETABLE CROP RESIDUES.

The regulation of crop residues must be guided by the new CAP strategies, promoting a diversified agricultural sector that helps to ensure food security, strengthening environmental protection (soil and water), but strengthening the socio-economic fabric in rural areas, which in turn boosts the incomes of farmers who will derive the best benefits from lower production costs.

The most reliable data on harvest indices on residual phytomass comes indirectly from the studies of the harvest index (IH), which is the relationship between crop yield - whether seeds, leaves, stems or edible roots - and the total phytomass of the crop in area. This proportion has been of great interest to plant breeders because impressive yield improvements during the 20th century have been the result of an overwhelming increase in the proportion of photosynthesis channeled into harvested tissues (Donald and Hamblin 1976⁷, Gifford and Evans 1981⁸, Hay 1995⁹).

There is no lack of published crop indices for the main crops, but the choice of average values for calculating national or global production of residues is difficult because the proportions vary, both between the main crops and for the same crop grown in different environments.

On the other hand, the HDI is also determined by agronomic factors that take into account the date of planting or the irrigation regime. In addition, experiments by Roberts et al (1993) showed that in the case of Californian aquatic seed rice, the HI varied more and decreased more rapidly with the increase in nitrogen applications in tall crops (from a maximum of 0,58 to 0,37) than in semi-deciform varieties (from 0,59 to 0,47)¹⁰.

From the data previously described by other authors, it can be deduced that the quantity and characteristics of the vegetable remains of the crops vary, and specifically taking into account the area of Almería, we have to take into account the crop in question, the type of greenhouse (a traditional greenhouse is not the same as an industrial greenhouse) and the specific campaign.

Following the aforementioned criteria, the following table shows the production indices of plant remains of the main greenhouse crops in Almería, according to two

⁶ "Lines of action in the management of plant remains in horticulture in Andalusia". Regional Ministry of Agriculture, Fisheries and Rural Development Regional Ministry of the Environment and Territorial Planning. September 2016.

⁷ Donald CM Hamblin J.: "The biological yield and harvest index of cereals as agronomic and plant breeding criteria". *Advances in Agronomy*. 1976. N° 28. Págs.: 361–405.

⁸ Gifford RM Evans LT: "Photosynthesis, carbon partitioning, and yield". *Annual Review of Plant Physiology*. 1981. N° 32. Págs.: 485–509.

⁹ Hay R.K.M. "Harvest index: A review of its use in plant crop physiology". *Annals of Applied Biology* 1995. N° 126. Págs.: 197–216.

¹⁰ Roberts SR Hill JE Brandon DM Miller BC Scarduci SC Wick CM Williams JF. Biological yield and harvest index in rice: "Nitrogen response of tall and semidwarf cultivars". *Journal of Production Agriculture*. 1993. N° 6. Pág.: 585–588.

consulted sources that differentiate the indices according to the type of greenhouse (traditional or industrial) for some crops.

As can be seen in the table, the indices of source A are significantly lower than those of source B (although source A explains that the indices are for the campaign periods of maximum generation of plant remains)¹¹. In both sources the crop that generates the greatest amount of remains per hectare is tomato.

It has been estimated the plant remains that can be produced in an average campaign for the main greenhouse crops in Almería. In crops where the first source gave two values (for two types of greenhouse), the lowest of them has been taken to make the estimate. An interval of production of remains has been estimated in which the quantity of remains produced each campaign will be found.

TABLE 2. Indices of production of plant remains for the main greenhouse crops in Almería.

	Residuos vegetales de invernadero (t/ha)		
		FUENTE A	FUENTE B
PIMIENTO	Inv. Tradicional	25,0	37,0
	Inv. Industrial	27,0	
TOMATE	Inv. Tradicional	35,0	73,3
	Inv. Industrial	45,5	
PEPINO	Inv. Tradicional	22,5	38,5
	Inv. Industrial	23,6	
CALABACÍN		22,5	44,5
BERENJENA		25,0	44,6
JUDÍAS VERDES		17,0	27,4
SANDÍA		15,0	17,0
MELÓN		23,0	33,2

Source: A: “La agricultura intensiva del Poniente almeriense. Diagnóstico e instrumentos de gestión ambiental” (Tolón y Lastra, Universidad de Almería). M+A. Revista Electrónica de Medio Ambiente 2010, 8:18-40. **B:** “Caracterización de los residuos vegetales de invernadero en Almería” (López *et al.*) VII Congreso Ibérico de agroingeniería y Ciencias Hortícolas, 2013.

Tal y como podemos ver en la tabla 3, más del 50% de los restos vegetales generados en Almería corresponderían a tomate y pimiento¹².

TABLE 3. Estimation of the production intervals of vegetable remains in the province of Almería, according to production areas

¹¹ https://www.juntadeandalucia.es/export/drupaljda/Acuerdo%20CG%20toma%20de%20razón%20restos%20vegetales%20368_16-APDR.pdf

¹² El territorio que corresponde a la OCA Campo de Dalías coincide con el de la Comarca Campo de Dalías considerada en esta Estrategia; la OCA Bajo Andarax- Campo de Tabernas incluye todos los municipios de la Comarca Campo de Níjar y Bajo Andarax, más otros municipios que no tiene gran representatividad en los cultivos de hortalizas de invernadero de la provincia. Son, en concreto, los municipios siguientes: Alcudia de Montegagud, Benitagla, Benizalón, Castro de Filabres, Lubrín, Lucainena de las Torres, Olula de Castro, Senés, Sorbas, Tahal, Tabernas, Turrillas, Uleila del Campo y Velefique.

	Producción estimada de restos vegetales en una campaña media (miles de TM)			
	OCA Campo de Dalías	OCA Bajo Andarax-Campo de Tabernas	Resto de OCA de Almería	Total provincial
PIMIENTO	205,5 – 304,1	12,2 – 18,0	1,8 – 2,7	219,5-324,8
TOMATE	114,7 – 240,3	229,0 – 479,6	16,8-35,1	360,5-755,0
PEPINO	95,3 – 164,3	11,8 – 20,3	0,8-1,3	107,9-186,0
CALABACÍN	109,6 – 216,8	40,9 – 80,8	1,5-2,9	152,0-300,6
BERENJENA	51,0 – 91,1	4,2 – 7,5	0,5-0,9	55,8-99,5
JUDÍAS VERDES	17,4 – 28,1	2,8 – 4,5	1,8-2,8	22,0-35,4
SANDÍA	52,7 – 59,7	27,5 – 31,2	4,4-5,0	84,6-95,9
MELÓN	49,7 – 71,7	6,4 – 9,3	2,6-3,7	58,7-84,7
TOTAL	696,0 – 1,176,1	334,8 – 651,3	30,1-54,5	1.060,9-1.881,9

Source: Regional Ministry of Agriculture, Fisheries and Rural Development and Regional Ministry of the Environment and Town and Country Planning (2016).

Until a few decades ago, the plant remains produced by agricultural activity were used as a source of energy, as organic amendments to the soil, as food for livestock or simply buried or burned. Nowadays the knowledge of new technologies makes possible the valorization of this organic matter in a more efficient and respectful way with the environment, using the by-products of one activity in the next and closing the productive cycles¹³, key ideas in the circular economy¹⁴ applied to the sector.

Hasta hace unas décadas los restos vegetales que producía la actividad agraria se utilizaban como fuente de energía, como enmiendas orgánicas para el suelo, como alimento para el ganado o simplemente se enterraban o quemaban. En la actualidad el conocimiento de nuevas tecnologías posibilita la valorización de esta materia orgánica de forma más eficiente y respetuosa con el medio ambiente, utilizando los subproductos de una actividad en la siguiente y cerrando los ciclos productivos, ideas clave en la economía circular aplicada al sector.

II. REGULATORY FRAMEWORK FOR CROP RESIDUES UNDER PLASTIC.

2.1 General reference framework through the Waste Directive.

¹³ Process of decomposition of organic remains mediated by the combined action of earthworms and microorganisms, from which a stabilized, homogeneous and fine grain final product is obtained called vermicompost or earthworm humus, very appreciated in the market.

¹⁴The circular economy is "an economic concept that is included in the framework of sustainable development and whose objective is the production of goods and services while reducing the consumption and waste of raw materials, water and energy sources". This is the definition made by the Circular Economy Foundation, which, as it points out, is based on the principle of "closing the life cycle" of any product. At the end of 2015, the European Commission adopted an ambitious package of measures on circular economy to be applied in companies and consumers with the aim not only of acting on climate change and the environment, but also to boost employment and economic growth.

In a European context where the production of waste is constantly increasing and where economic activity linked to waste is becoming increasingly important, both because of its scale and because of its direct impact on the sustainability of the European economic model, the Sixth Community Environment Action Programme called more than a decade ago for a review of waste legislation, a clear distinction between waste and non-waste, and the development of measures relating to waste prevention and management, including the setting of targets. In the same vein, the Commission Communication of 27 May 2003 "Towards a Thematic Strategy on the Prevention and Recycling of Waste" called for progress in its revision.

However, to date, although harvest residues are partially excluded from the Directive while remaining on the farm, they could be classified as such under the definition given in Art. 3 of the Waste and Contaminated Soil Act¹⁵: "any substance or object which the holder discards or intends or is obliged to discard", as regulated by Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste, which establishes the European Union's legal framework for waste management, provides the tools to dissociate the relationship between economic growth and waste production, with particular emphasis on prevention, understood as the set of measures taken before a product becomes waste, to reduce both the quantity and content of hazardous substances and the adverse impacts on human health and the environment. It thus incorporates the principle of hierarchy in waste production and management which should focus on prevention, preparation for reuse, recycling or other forms of recovery, including energy recovery, and aims to transform the European Union into a "recycling society" and contribute to the fight against climate change. All these matters are necessary to be determined in a future regulation of crop residues, where the rights and obligations of the different agents are determined: public administrations, producers and managers of vegetable residues (producers, transporters, processing companies); and, on the other hand, the prevention, production and management of vegetable residues together with the principles that inspire it, based on environmental sustainability and the profitability of rural areas.

This profitability requires regulations that promote the implementation of prevention measures, the reuse and recycling of plant remains, or disposal by incineration through its valorization at the level of energy efficiency; it also aims to increase the transparency and environmental and economic efficiency of the different activities.

Finally, it is part of the spirit of any regulation of this nature to facilitate the development of the same by providing lines of support for solutions with greater value for society at all times, which will complement the objective of environmental sustainability, reducing greenhouse gas emissions associated with this sector and contributing to climate conservation.

2.2 Transposition of the Directive: exclusion of crop residues.

¹⁵ Ley 22/2011, de 28 de julio, de residuos y suelos contaminados. «BOE» núm. 181, de 29/07/2011. BOE-A-2011-13046. <https://www.boe.es/eli/es/l/2011/07/28/22/con>

In accordance with the Waste Directive¹⁶, which does not include agricultural waste used in the agricultural sector or used for energy production, and its transposition into Law 22/2011 of 28 July on waste and contaminated soil (transposition of the Waste Framework Directive) and the Waste Regulation of Andalusia, which applies to all waste, we should remember that it only excludes from its scope "faecal matter [...]"....], straw and other natural, agricultural or forestry material, non-hazardous, used in agricultural and livestock farms, in forestry or in the production of energy from this biomass, by means of procedures or methods that do not harm the environment or endanger human health".

Therefore, plant remains that are not excluded from the scope of the Law as mentioned above, are considered waste and their management is conditioned to what is contained in the aforementioned regulations, in Law 7/2007 of Integrated Management of Environmental Quality (Law GICA)¹⁷ and in Decree Law 5/2014 of regulatory measures to reduce administrative burdens for companies.

Currently, the management of crop residues does not have a specific regulation and its generic regulatory framework does not resolve the doubts generated by its use, since although by analogy we could in some cases apply the regulation referring to waste, this does not include organic matter or non-commercial production that has not yet left its production environment, as it is initially inside the greenhouse, although at a later time its end could be for the sector itself, for livestock feed¹⁸, for bio-waste or for energy production.

III. USE AND MANAGEMENT OF HARVEST RESIDUES DERIVED FROM GREENHOUSES.

¹⁶ DIRECTIVA 2008/98/CE DEL PARLAMENTO EUROPEO Y DEL CONSEJO de 19 de noviembre de 2008 sobre los residuos y por la que se derogan determinadas Directivas. DOUE 22.11.2008. Actualmente existe un borrador de ley nacional de 2010. Borrador de Anteproyecto de ley de residuos y suelos contaminados. (Versión de 10 de junio de 2010). https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/participacion-publica/borrador_anteproyecto_residuos_10junio_tcm30-98710.pdf

¹⁷ Ley 7/2007, de 9 de julio de Gestión Integrada de la Calidad Ambiental. Comunidad Autónoma de Andalucía «BOJA» núm. 143, de 20 de julio de 2007 «BOE» núm. 190, de 9 de agosto de 2007 Referencia: BOE-A-2007-15158.

¹⁸OM AAA/699/2016 of 9 May (modifies operation R1 of Annex II of L 22/2011 of 28 July, waste and contaminated soil). Art. 24: The environmental authorities will promote, without prejudice to the measures deriving from the actions undertaken at Community level in compliance with the last paragraph of Article 22 of Directive 2008/98/EC, measures that may be included in the waste management plans and programmes provided for in Article 14, to promote:

a) separate collection of bio-waste for composting or anaerobic digestion, in particular of the plant fraction, bio-waste from large generators and bio-waste from households.

b) Household and community composting.

c) The treatment of separately collected bio-waste in such a way as to achieve a high degree of environmental protection carried out in specific installations without mixing with mixed waste throughout the process. Where appropriate, the authorisation of this type of installation shall include technical requirements for the correct treatment of bio-waste and the quality of the materials obtained.

d) The use of compost produced from bio-waste and environmentally safe in the agricultural sector, gardening or the regeneration of degraded areas, replacing other organic amendments and mineral fertilisers.

The control of harvest remains on the eastern coast of Andalusia, their use and their management are determining factors for intensive horticultural production in greenhouses, which has been directed for years towards the development of a model that respects the environment in our productive sector, under the sustainable use of phytosanitary products and under the biological control that has been applied in the last two decades. This has led us today to actions that address the management of plant remains from the perspective of the concept of circular economy, bioeconomy and symbiosis between the different agents involved, so that the plant remains can be valued in a more efficient way, closing the production cycles.

It is true that when the harvest is withdrawn at the end of the campaign, next to the remains of the crop that is produced in the greenhouses: stems, leaves, fruits of destruction that do not meet the necessary quality standards or that are not marketed for market reasons and complete plants that are uprooted at the end of cultivation cycles, there is also the presence of plastic elements such as the threads used to staut the crops and that grow upright in a vertical direction, for which a polypropylene raffia is usually used that is not biodegradable and that must be separated from organic matter, which is our legal good to regulate, knowing that this involves a cost for the farmer, who will be willing to pay if in addition to providing sustainability benefits derived from its production.

So that we can better understand what expense we are referring to, let's take the tomato as an example, as it is the one that produces the most crop extension in Almería. If we look at table 4 below, separating non-biodegradable elements, such as raffia threads to staking tomatoes and plastics, has a cost of 0.045 euros per square meter, to which we must add the management of raffia threads which represents 0.018 euros per square meter, plus the crushing of plant remains which is where the farmer can get the added value to their production, and which represents a cost of 0.103 euros per square meter.

TABLE 4. Cost of raffia management and crushing of harvest remains.

PARTIDAS	COSTE (€/M ²)
Separación de la rafia y elementos plásticos	0,045
Gestión de rafias	0,018
Trituración de restos vegetales	0,040
TOTAL	0,103

Source: Agronomic use of plant remains in greenhouses, 2014. (Torres Nieto, J.M.). Costs are quantified for the plant remains of a tomato crop.

With these data, we can summarize that for the farmer the separation and management of raffia and plastics, together with the shredding of crop residues in an average greenhouse of one hectare is approximately 1030 euros per harvest, so that a year we would speak of more than 2000 euros of costs to be borne by the farmer.

3.1 Characteristics of crop residues: their use and management.

Considering the tonnes, seasonality and the cost added to the farmer to obtain the biomass, it is easy to understand the need for a regulation on the handling and management of crop residues for subsequent use, being decisive to keep them exclusively, as they are characterised by specific and concrete properties:

- They have a high moisture content (up to 60% at the time of withdrawal),

- They have a high salt content.
- They are easily biodegradable.

These physical-chemical characteristics of the remains of organic matter have a high degree of humidity and a low weight/volume ratio¹⁹, so they need a minimum time for their degradation to occur. This condition is important in what the fertility of the soil affects, because it is buried and mixed with the soil or sanded, increasing the nutrients of the soil where the next crop will be cultivated; although when the productive system is not done under soil but in perlite, hydroponic or coconut fiber, and consequently, no soil is required for production, these remains must be removed before starting the next crop. Hence the need for an adequate and close regularization in time to collect the measures of prevention and transparency under environmental and economic efficiency.

One of the uses of the remains of harvest affects the soil, both in contribution of natural fertilizers that allows us to reduce the use of inputs, and consequently, greater and better sustainability, and parallel with the biodisinfection of the soil providing large amounts of organic matter to decompose within the soil and produce sterilizing effects²⁰, and if the above is covered with plastic without leaving a hole watering abundantly during the month of July, reaching 70 degrees with the summer heat, is called biosolarization²¹.

But the remains of harvest, have other uses outside the greenhouse. In this sense, for example, we can talk about when a transformation is required (composting or other modalities), becoming fertilizer, or going to feed for livestock, or being eliminated via landfill. For this reason, and taking into account the use to which they are destined, it must be remembered that the Plant Health Law²² applies to them, and it is the duty of the owner of the holding to prevent the spread of pests and diseases (Ministry of Agriculture, 2012), where maximum phytosanitary limits are regulated for residues in the plants, their products and their transformations²³, although we must note that at the end of the campaign there are few phytosanitary remains that exist in all production.

¹⁹ They have a variable density between 75 and 200 kg/m³ and a variable C/N ratio that can vary between 15 and 30.

²⁰ JOSE MANUEL TORRES NIETO: "Uso agronómico de restos de cosecha en los invernaderos enarenados de la cuenca mediterránea". CAJAMAR. July 2016. https://www.researchgate.net/publication/278302016_USO_AGRONOMICO_DE_RESTOS_DE_COS_ECHA_EN_LOS_INVERNADEROS_ENARENADOS_DE_LA_CUENCA_MEDITERRANEA. The author considers the management of harvest remains from planting to completion of the crop inside the greenhouse by considering biodisinfection valorization with harvest remains (COL) as the most efficient and profitable way to manage local resources (Bello et al., 2008a; Diez-Rojo et al., 2010b; Torres et al., 2007; Torres-Nieto, 2007).

²¹ The use of fresh crop remains as a resource becomes valuable in soil biodisinfection (Bello et al., 2008b, 2000) understood as the set of techniques, which include biofumigation and biosolarization, that allow the restoration of soil health, even when sick crop remains are used (Vilaseca et al., 2006; Zanón M.J., Vilaseca J.C., Rodríguez J.M., Heliodoro J.S., 2004; Zanón, 2009; Zanón et al., 2011).

²² Ley 43/2002, de 20 de noviembre, de Sanidad vegetal. BOE» núm. 279, de 21 de noviembre de 2002 Referencia: BOE-A-2002-22649.

²³ **Article 42.** Maximum residue limits.

1. Plants, plant products and their processed products, intended for human or animal consumption, may not contain, from the moment of their first commercialization after harvest, or from the exit of the warehouse in case of post-harvest treatment, residues of phytosanitary products at levels higher than the maximum limits established by regulatory standards, following a report from the Joint Commission on Residues of Phytosanitary Products.

2. The provisions of the previous paragraph shall not apply to plants, plant products and their processed products intended for planting or sowing or for the manufacture of products not intended for human or animal consumption.

On the other hand, we must bear in mind that not only the remains of the harvest remain in greenhouses for the fertility of the soil, but in most cases, they are removed and come out of it, although in both cases it is necessary to avoid any phytosanitary risk and regulate their use and management accordingly.

In this regard, it should be pointed out that, if plant remains are not well managed under the principle of prevention and appropriate measures, they can be vectors of pests and diseases, which is why there are specific health regulations in various areas that regulate their management. In addition, we must bear in mind that they may contain a certain concentration of phytosanitary residues, which is important to bear in mind if they are destined for animal feed, although it must also be mentioned that when they are produced at the end of the cultivation cycle, they will rarely present worrying contents, since weeks will have passed since the last applications, if the product safety deadlines have been properly respected.

Finally, we must point out that this is organic material which easily generates liquid fractions, which can leach causing contamination of aquifers, risks which will have to be taken into account under the principle of prevention in the regulations regulating the vegetable remains of harvest.

3.2 The actors involved in the different forms of management of crop residues.

At present, plant debris from greenhouse cultivation may have different destinations involving different forms of management²⁴:

1. Delivery to an authorised manager. When plant remains are managed (in this case under the legal nature of waste) through their delivery to an authorised manager, it is the farmer who bears the cost of the removal service and transport to a treatment plant²⁵. The price of this service usually depends on the volume to be transported. This destination implies the participation of another agent in the chain, the transporter, who acts as an intermediary between the farmer and the management plant and whose activity requires prior authorisation from the regional administration.

2. Use or reuse of plant remains on the farm itself: Self-management of the harvest remains is another possible destination for the biomass from the crop. There are two options to take advantage of it, its use buried in green or self-composting.

Regarding the role to be played by each of the agents involved in the actions:

- The farmer is the active subject of any initial action because he is the one who produces the crop residues and consequently the person responsible for it. For this reason, he must try to maximise the volume of vegetable waste that he can self-manage or valorise, either individually or through the producer groups in which he is integrated, so that he can introduce them back into his production process, thereby increasing his efficiency in the use of inputs. This can be achieved through self-composting and burial in green, or through other forms of valorization with which yields are obtained in addition to mere management as would be the task of crushing

²⁴ “La agricultura intensiva del Poniente almeriense. Diagnóstico e instrumentos de gestión ambiental” (Tolón y Lastra, Universidad de Almería). M+A. Revista Electrónica de Medio Ambiente 2010, 8:18-40.

²⁵ A process in which aerobic biological decomposition of organic debris occurs under controlled conditions.

or chopping the remains, as it facilitates the management of the remains, whatever their subsequent destination.

- Producer groups (cooperatives, SATs, OPFH) are a key element for optimised management, as a service to their farmers and as an example of clean management of the market.

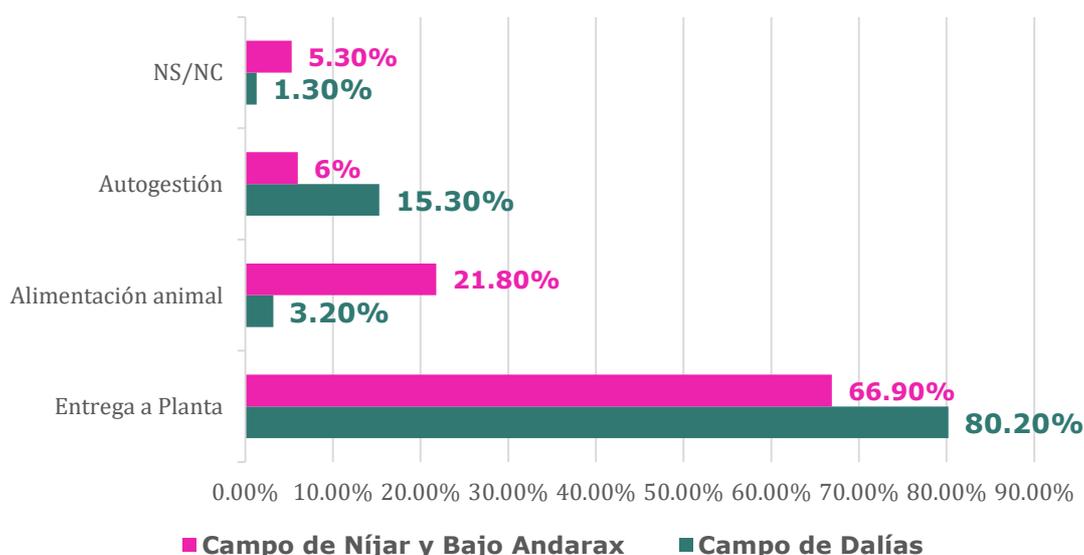
- In cases where it is necessary to transport the plant remains to the transfer or recovery plants, it is essential for the transporter to authorise a sufficient fleet to manage the transfer of tonnes of plant remains that are generated at two specific times in the year corresponding to the end of the campaigns, together with the development of route optimisation systems.

- The regions have a key integrating role in the improvement process, as they have the possibility of drawing up a public incentive plan that facilitates and promotes actions with good practices, as well as developing a diagnosis of the regulations for their optimisation following the harmonising role of the State in compliance with European regulations. At the same time, local entities can contribute to the search for sites for the network of small treatment plants and collaborate in their implementation, as this improves the per capita income of the farmer, who converts part of the production costs into profit, thus improving both the family economy and that of the region; together with the improvement and environmental sustainability of the area.

- The research centres must work on new management systems for the remains inside and outside the greenhouse, new forms of plant valuation and diversification of the uses of the resulting products; together with an appropriate and proportional regulatory framework yet to be developed.

- Finally, waste managers must be able to innovate both in processes and in management models in order to be more effective and obtain yields.

FIGURE 5. Majority destination of plant remains generated in greenhouses (percentage of farms).



Source: Regional Ministry of Agriculture, Fisheries and Rural Development and Regional Ministry of the Environment and Town and Country Planning (2016).

All this intensive production, and its management of vegetable waste has great repercussions at an environmental level, as well as other challenges faced by the Almeria countryside for environmental sustainability and the maintenance of economic growth, especially in matters of water resources, solid waste and pollution from the use of fertilizers and pesticides, which makes us move towards an agriculture based on the circular economy, in which we achieve greater use of our resources and give a second life to the remains of the harvest in benefit of producer profitability, food safety and environmental sustainability.

IV. GUIDING PRINCIPLES AND ROLE OF THE ACTORS INVOLVED.

The lines of action for the management of plant remains in horticulture on the eastern coast of Andalusia arise from the producing sector itself, which, knowing the problems involved in the management of crop remains, is determined to provide a solution, moving forward with a production model that respects the environment based on the circular economy, which allows it a benefit by lowering production costs, as it would be less need to buy fertilizers and inputs in the season, or obtaining an income from its transformation or use in addition to that which would be the sale for feeding livestock.

The remains of the harvest, understanding it as biomass, is an area of intersection between different administrations and regional Councils, which is subject to European regulations under the regulation of plant health standards and environmental sustainability, which makes it difficult to regulate. This is why it is necessary to articulate measures that, safeguarding the sense of protection and respect for the environment, promoting a standard that avoids distortions and facilitates the management of plant remains by farmers and other agents involved, is an unequivocal definition of what is meant by harvest remains, determining what criteria are required for their management according to the use to which they are intended, awarding certifications relating to environmental sustainability for the benefit of the circular economy, with a view to protecting, preserving and improving the quality of the environment, as well as protecting human health, ensuring the prudent, efficient and rational use of natural resources, through additional measures on sustainable production and consumption, focusing on the complete life cycle of products, in a way that preserves resources and closes the circle.

Thus, the main challenge in the lege ferenda proposal lies in the use and management of the crop that requires policies that maximize the probability of profitability and sustainability, since, as we have pointed out, there is a great gap in our knowledge about the implementation of harvest regulations that affect control methods and that determines how the residual crop is inadequately managed, which weakens the world's food production capacity and contributes to an undesirable biospheric change. Harvest residues should not be seen as residues but as providers of essential environmental services, ensuring the perpetuation of productive agroecosystems.

To this end, measures are required that are regulated and aimed at protecting the environment and human health, ie, must be determined the systems of prevention and / or reduction of the generation of crop residues and the negative impacts of their generation coupled with their management, in order to improve the efficiency of such use. This general purpose will be translated into a norm that it determines in a specific way:

- Dangerous vegetable harvest residues (may cause risk) of those that are not.
- Determination of phytosanitary limits in plant remains, taking into account their subsequent use.
- Percentage limits that are not allowed as crop residues per hectare without a destination according to the strategies determined by the EU.
- The distribution of responsibilities for waste management between public and private agents, from the producer.
- Measures to encourage the proper use of crop residues.
- The procedure for selecting operators for the management of plant debris.
- Measures for the prevention of crop residues in accordance with sustainable consumption.
- Valorisation: regulating the measures that guarantee that the harvest remains are prepared for reuse, recycling, biowaste or biodisinfection.
- Alert systems and data communication.

All of these measures are necessary for the management and reduction of greenhouse plant remains, from administrative governance based on an appropriate regulation to bioeconomy, to move towards a more sustainable management of the agri-food complex, including new processes that allow diversification of results and optimum use of resources, thus favouring the aforementioned commitment to encourage the transition to a circular economy.

These measures shall seek to provide a response to the farmer, with his own involvement in solving the problems, either individually, through the promotion of green manure and self-composting, or collectively, through producer organisations. To this end, measures are proposed for investments in farms, as well as in plants for the transfer and recovery of plant remains, in order to deploy on the ground a network for the management of plant remains that covers all phases (collection, pre-treatment, recovery, etc.), and that in turn bets on small and medium-sized facilities in order to obtain an articulated, flexible and environmentally efficient economic and economic model.

V. CONCLUSIONS.

The economic and agronomic data have shown the seasonality and accumulation of tons that well managed, can be an added value to the producer and therefore to the region and the environment, in addition to the consumer.

Unfortunately, there is no legislation regulating the use and management of crop residues, not even a preliminary draft that makes progress on a complicated issue as far as competition is concerned, as Spain has delegated powers in agriculture to the Autonomous Regions, and although the EU includes the issue in its CAP strategic lines for the coming years, so far no first steps have been taken.

On the other hand, not all agricultural territories collect the economic and agronomic data of the remains of the harvest, nor of their use and management, causing, together with the legal gap, a lack of information necessary to address possible risks of contamination of the soil or aquifers.

Finally, control systems and guarantees are necessary in the regulation of all economic activity, and specifically, as in our case, of the primary sector, for a competitive and sustainable development.