ECONOMIC RESPONSE OF INDUSTRIAL CROPS TO DRIP AND HOSE-REEL IRRIGATION: ON-FARM COMPARISONS IN CENTRAL AND NORTHERN ITALY

REPONSES ECONOMIQUE DES CULTURES INDUSTRIELLES IRRIGUEES PAR SYSTEMES D'IRRIGATION GOUTTE-A-GOUTTE ET ASPERSION AVEC ENROULEURS : COMPARAISON ENTRE LES FERMES DE L'ITALIE CENTRALE ET SEPTENTRIONALE

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ABSTRACT

A triennial research aiming at comparing the agronomic and economic performance of drip and hose reel irrigated industrial crops started in the 2009 cropping season on some irrigated mid-size farms, located in Central and Northern Italy. The Selection of farms was made accounting for the current on-farm practices, such as the simultaneous use of both drip and hose reel systems on the same crop during the same season, and the actual on-farm irrigation management aiming at yield maximization. Economic comparison was made on Tobacco, processing Tomato, Silage Maize and Onion, according to the parameters seasonal irrigation supply, marketable production, irrigation cost and gross income. This paper illustrates the results obtained during the 2009 and 2010 cropping seasons. Irrigation water supplied by hose reel booms and guns was lower than under drip lines in most cases (75%), while the gross income of market yield was higher in about half the cases. Comparison according to irrigation cost and gross income shows that the cost per hectare of hose reel irrigation is lower in all cases in the farms under analysis, the advantage being equal to about 55% on average. The advantage on gross income of the hose reel irrigation is about 1% on average with respect to drip irrigation. Results depict a better economic suitability of hose

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reel irrigation with respect to drip water supply. However, under the same farming conditions and professional skills, there is no evidence of any system supremacy on water saving and crop yield. Moreover, irrigation management is crucial on crop yield and water use.

Key words: *Irrigation management, Drip, Hose reel, Economic evaluation, Tobacco, Onion, Italy.*

RESUME ET CONCLUSIONS

Le Département de Economia, Ingegneria, Scienze e Tecnologie Agrarie e Forestali (DEISTAF) de l'Université de Florence a dirigé une recherche sur trois années, à partir du 2009, sur des fermes de dimensions moyennes de l'Italie centrale et septentrionale. Objectif étais de confronter les réponses en sens agronomique et économique des cultures industrielles irriguées par systèmes d'irrigation goutte-à-goutte et aspersion avec enrouleurs. Le choix des fermes a été fait en considérant les pratiques d'irrigation adoptées, voir l'utilisation des systèmes goutte à goutte et avec enrouleurs sur la même culture et en même saison et sur la capacité des agriculteurs de gérer l'irrigation dans le bout de maximiser la production agricole.

La comparaison économique se fait sur le Tabac, le Tomate industriel, le Mais ensilé et l'Oignon à travers les paramètres: eau d'irrigation, la production commercialisable, coût de l'irrigation et le revenu brut. Ce document présente les données recueillies au cours de saisons 2009 et 2010. La quantité saisonnière d'eau d'irrigation distribuée par les enrouleurs était inférieur à celui distribué par la goutte-à-goutte dans la plupart des cas (75%), ainsi que la production commercialisable avec irrigation goutte-à-goutte a été améliorée dans la moitié des cas. L'évaluation du coût d'irrigation a été faite au niveau parcelle de terrain. On a considéré uniquement les coûts spécifiques de l'irrigation, sans considérer les coûts d'entreprise n'affectent pas la comparaison. Le coût de l'eau utilisée pour l'irrigation est calculé à zéro. Dans la procédure adoptée pour calculer le Coût d'Irrigation, l'énergie employée représente la voix principale pour l'irrigation par enrouleurs et constitue en moyenne le 54.6% du coût total de l'irrigation. L'amortissement compte pour le 34.3% et la main d'œuvre pour le 11.1%. Pour l'irrigation goutte-à-goutte, l'achat et l'élimination des tuyaux d'écoulement compte le 51.1% du coût total de l'irrigation, la main d'œuvre pour la mise en place et le démontage des composants compte le 28.8%, l'énergie le 16.1% et l'amortissement et l'entretien le 4.0%.

La comparaison entre les indices du coût de l'irrigation et de revenu brut montrent que dans les fermes étudiées le coût par hectare pour irrigation par enrouleur est toujours inférieur au coût pour l'irrigation goutte à goutte, par un avantage moyen du 65%. En termes de revenu brut, l'avantage moyen de l'irrigation par enrouleur est du 0.7%. L'efficience économique pour chaque méthode a été évaluée à travers deux indices spécifiques. Le premier considère la différence entre les coûts soutenus pour obtenir les deux revenu brut. Cet indice peut montrer la contribution à la rentabilité du point de vue économique, sans compter l'influence des autres facteurs productifs. Le second indice se base sur le coût de l'unité d'eau pour l'irrigation (m3), et nous permet la comparaison entre l'efficience économique de l'eau distribuée sans considérer l'efficacité agronomique de l'eau utilisée. Les deux indices montrent

un avantage majeur pour l'irrigation avec enrouleurs par rapport à la goutte-à-goutte. Les résultats de cas d'étude présentent une meilleure réponse économique de l'irrigation par enrouleurs par rapport à celle goutte-à-goutte. Cependant le résultat, les plus relevant, est que dans les mêmes conditions environnementales et de compétence professionnelle, il n'y a pas vraiment une suprématie d'une méthode sur l'autre par rapport à la quantité d'eau utilisée et à la rentabilité agricole. Sur la base des résultat de terrain, il semble que dans des conditions de culturales normales, la gestion de l'irrigation soit déterminante sur la rentabilité de la production agricole et sur l'usage de l'eau.

Mots clés : *Gestion d'irrigation, irrigation goutte à goutte, enrouleurs, évaluation économique, tabac, oignon, Italie.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Dramatic decline of water allocation to agriculture is expected in the near future due to a low investment rate as compared to other sectors. Today, irrigation is a key factor in confronting the global food security challenge and insuring the economic profitability of agriculture. Irrigated farming needs attention in selecting irrigation system and management, in order to achieve both individual and general objectives, such as the increase of farm net income and the saving of water for other uses. Sellers of irrigation equipment, and public and private institutions worldwide, frequently support the concept that the efficient use of irrigation water, as well as the profitability of the irrigation practice, lays more on the technical and working characteristics of a given system (i.e., micro) than on the management of the system itself. Moving from such premises, a triennial research project started in 2009 under the scientific supervision of the Department of Agricultural and Forest Economics, Engineering, Sciences and Technologies of the University of Firenze. The aim of the project is to compare the agronomic and economic performances of some industrial crops, irrigated by drip and hose reel systems under the same agronomic and climatic conditions. Field activity is carried out in some medium-size farms, whose selection was made accounting for the current on-farm practices, such as the simultaneous use of both drip and hose reel systems on the same crop during the same season, and the actual on-farm irrigation management aiming at yield maximization. Results presented in this paper refer to 2009 and 2010 cropping seasons.

2. MATERIALS AND METHODS

2.1 Crops and parameters

The research, was carried out on 11 farms, measuring from 50 to 170 ha, located in Central and Northern Italy (Figure 1). Each on-farm annual analysis represents a case study.

Fig. 1. Farms location in Central and Northern Italy (Localisation des fermes en Italie du Centre-Nord)

Economic comparison was carried out on processing Tomato (n. 5 case study), Onion (n. 2 case study), Tobacco (n. 3 case study) and Silage Maize (n. 2 case study). Comparison was made taking into account the gross income (GI) given by each cultivation process, and the costs relative to the irrigation practice (IC), according to the data collected in Annex 1.

Since selection criteria of the plots under analysis enable to consider local conditions (i.e., soil type) and cultivation activities to be equal or at least not relevant on the crop response, the irrigation method is credited as being the only variable in the comparison of the production process. Results are expressed in the form of indexes by calculating percentage difference, called here *advantage*, between the values of each parameter yielded under each irrigation type. This way, an assessment on the investigated variables, as well as a comparison among case studies, can be made regardless of the absolute value of each variable. Data in this paper refer to 1 hectare. Comparison between irrigation methods is made by assuming drip irrigation as bench mark. Assessment of GI is made by examining GI attained under both sprinkler (GI_S) and drip (GI_D) irrigation. The difference GI_S-GI_D describes the *advantage* of sprinkler irrigation compared to drip irrigation. Assessment of IC considers the IC of drip (IC_D) and sprinkler (IC_S) irrigation. The difference IC_D-IC_S describes the *advantage* of sprinkler

irrigation as compared to drip irrigation (positive IC_S advantage means lower IC). Some technical and economic parameters concerning water use have been considered (Annex 2). They relate GI and IC to the unit of supplied water (m^3).

2.2 Production index

Gross income (GI) index enables to assess the influence of each irrigation type on amount and quality of the crop market yield (MY). GI includes the bearing of quality parameters on market price (e.g., °Brix of processing Tomato, Onion size). Comparison is made by calculating GI according to the *advantage* of sprinkler over drip irrigation:

$$GI_{adv} = \frac{(GI_S - GI_D)}{GI_D} x100$$

Where: GI_{adv} = advantage of sprinkler over drip irrigation about GI (%);
GI_S = Gross income under sprinkler irrigation (€/ha);
GI_D = Gross income under drip irrigation (€/ha).

2.3 Cost index

Assessment of irrigation costs (IC) considers the difference between drip (IC_D) and sprinkler (IC_S) irrigation. This approach enables us to ignore components regarded as equal. The total cost of irrigation is given by both individual and shared costs, the latter being part of common production factors used also in other cropping activities (i.e., tractors). In the farms under analysis, the use of common factors is similar under the different irrigation types. Therefore, only the difference between specific costs was considered. The quota concerning production factors used for other in-farm activities (i.e., pumps, water delivery systems) was ignored for the same reason, and the survey is restricted to the costs concerning the plots under analysis. Amortization of the irrigation equipments refers to the hectare. Specifically, filters are considered in drip systems, hose reel machines in sprinkler systems. Cost comparison is made according to the specific costs meet for irrigating a specific plot (SPC), represented by the sum of monetary costs, MC (i.e., labour, raw materials, consumables, services and cost of energy) and calculated costs, CC (i.e., amortization). SPC includes the cost of energy (fuel and electric power) for water lifting. The cost of irrigation water is zero in the project areas.

Comparison of IC among the different crops is enabled by the SPC_{adv} index, which represents the *advantage* of sprinkler (SPC_S) compared to drip (SPC_D) irrigation:

$$SPC_{adv} = \frac{(SPC_D - SPC_S)}{SPC_D} x100$$

Where: SPC_{adv} = advantage of sprinkler over drip irrigation about SPC (%);
SPC_S = plot costs under sprinkler irrigation (€/ha);
SPC_D = plot costs under drip irrigation (€/ha).

Specific and average cost composition is displayed in Table 1.

2.4 Productivity index

Assessment of the economic efficiency of any irrigation type requires the computation of the economic cost of each operation involved in the production process. However, evaluation of the economic results achieved in each case study by different irrigation methods is made possible by the monetary assessment of the difference between GI and SPC, which represents the available economic resource (AR) to remunerate the production factors used in the other cropping operations. Under the assumptions made and the simplification taken, the cost of the other cropping practices (OC) is similar, and the difference between available economic resource allowed by sprinkler (AR_S) and drip (AR_D) irrigation represents the difference between incomes (ID). Rough evaluation of the irrigation-type convenience is allowed within each case study as follow:

$$ID = \left(GI_S - SPC_S - OC\right) - \left(GI_D - SPC_D - OC\right) = \left(AR_S - AR_D\right)$$

Where: ID = difference between incomes (€/ha);
OC = cost of the other cropping practices (€/ha);
AR_S = available economic resource allowed by sprinkler irrigation (€/ha);
AR_D = available economic resource allowed by drip irrigation (€/ha);
GI_S, GI_D, SPC_S, SPC_D = as formerly defined.

However, since the absolute value of ID depends on crop type, agro-environmental conditions, and other costs of the cropping technique, comparison between the different case studies can be made by the *advantage* given by the difference between AR_S and AR_D, according to the index:

$$AR_{adv} = \frac{\left(AR_S - AR_D\right)}{AR_D} x100$$

Where: AR_{adv} = advance of sprinkler over drip irrigation about AR (%);
AR_S, AR_D = as formerly defined.

2.5 Water use indexes

- **Relative Surplus**

  For each case study, both sprinkler and drip irrigation management can be assessed through the index relative surplus (RS), which compares the actual irrigation supply (SIS) to the net irrigation requirement (NIR), both calculated on seasonal basis and defined as follows:

$$RS = \frac{\left(SIS - NIR\right)}{NIR} x100$$

  Where: RS = Relative Surplus (%);

SIS = Seasonal Irrigation Supply (m^3/ha);
NIR = Net Irrigation Requirement[1] (m^3/ha).

- **Seasonal Irrigation Supply**

Comparison of water use is made on SIS. The index SISadv is arranged according to the same criteria formerly used to define the concept of advantage:

$$SIS_{adv} = \frac{\left(SIS_D - SIS_S\right)}{SIS_D} x100$$

Where: SIS_{adv} = advance of sprinkler over drip irrigation about SIS (%);
SIS_D = seasonal supply under drip irrigation (m^3/ha);
SIS_S = seasonal supply under sprinkler irrigation (m^3/ha);

- **Agronomic Efficiency**

Agronomic efficiency (GIEFN) defines the performance of irrigation water when it is used in the framework of specific production techniques, that is the suitability of the irrigation type to the selected technique:

$$GI_{EFN\,adv} = \frac{\left(GI/m^3{}_S - GI/m^3{}_D\right)}{GI/m^3{}_D} x100$$

Where:
GI_{EFNadv} = advance of sprinkler over drip irrigation about GI_{EFN} (%);
$GI/m^3{}_S$ = economic productivity of the water unit under sprinkler supply (€/m^3);
$GI/m^3{}_D$ = economic productivity of the water unit under drip supply (€/m^3).

- **Economic Efficiency**

Economic efficiency (SPC_{EFN}) describes the economic performance of the water supply, regardless of the results obtained:

$$SPC_{EFN\,adv} = \frac{\left(SPC/m^3{}_D - SPC/m^3{}_S\right)}{SPC/m^3{}_D} x100$$

Where:
SPC_{EFNadv} = advance of sprinkler over drip irrigation about SPCEFN (%);
$SPC/m^3{}_D$ = specific costs met for the drip supply of the water unit (€/m^3);
$SPC/m^3{}_S$ = specific costs met for the sprinkler supply of the water unit (€/m^3).

1 NIR refers to the irrigation season and is calculated by assessing crop evapotranspiration (ETc), effective rainfall and soil moisture variation in the active rootzone.

♦ **Economic Effectiveness**

Economic effectiveness (AR_{EFC}) defines the effectiveness of the irrigation method as economical increase of the water used:

$$AR_{EFCadv} = \frac{\left(AR/m^3{}_S - AR/m^3{}_D\right)}{AR/m^3{}_D} x100$$

Where:
AR_{EFCadv} = advance of sprinkler over drip irrigation about AREFC (%);
$AR/m^3{}_S$ = economic effectiveness of the sprinkler supplied water unit (€/m^3);
$AR/m^3{}_D$ = economic effectiveness of the drip supplied water unit (€/m^3).

3. RESULTS AND DISCUSSION

3.1 Gross income

Difference between the GI yielded by methods varies significantly within the case studies. The advantage of sprinkler irrigation, described by the index GI_{adv}, is illustrated in Figure 2. The index varies from – 22% to 34%, and despite it is negative in 7 cases out of 12, the average value is slightly positive (0.7%). With respect to GI, there is no evidence for the superiority of one method to the other, since results of some crops cultivated in the same farm and soil type are opposite from one season to the next.

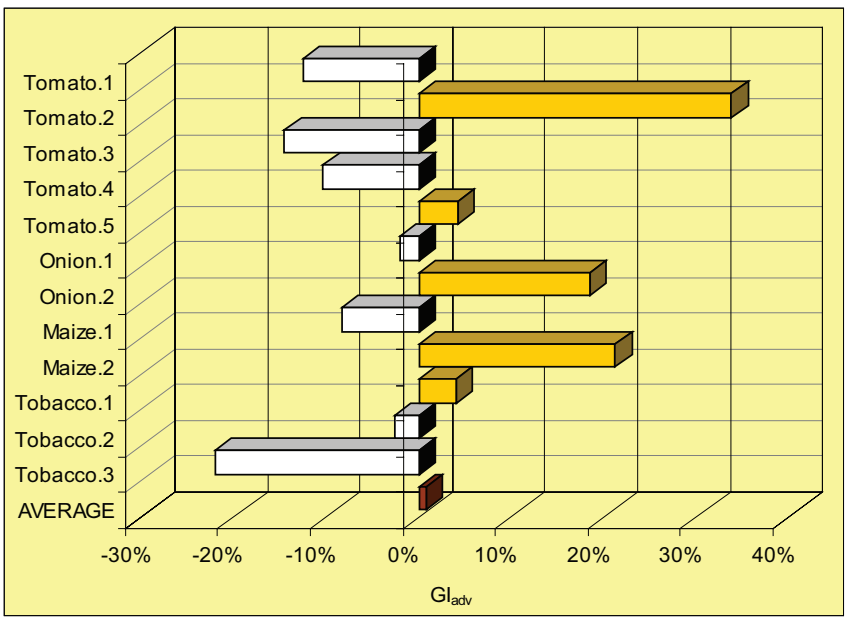

Fig. 2. Advantage of sprinkler on gross income (Avantages de l'irrigation par aspersion sur le revenu lourd)

3.2 Cost

Comparison of IC shows great variability among farms. Nevertheless, sprinkler irrigation is less expensive than drip irrigation in all cases (Table 1). The SPC_{adv} index ranges from 4% to 88% (Figure 3) and the advantage is about 55% on average.

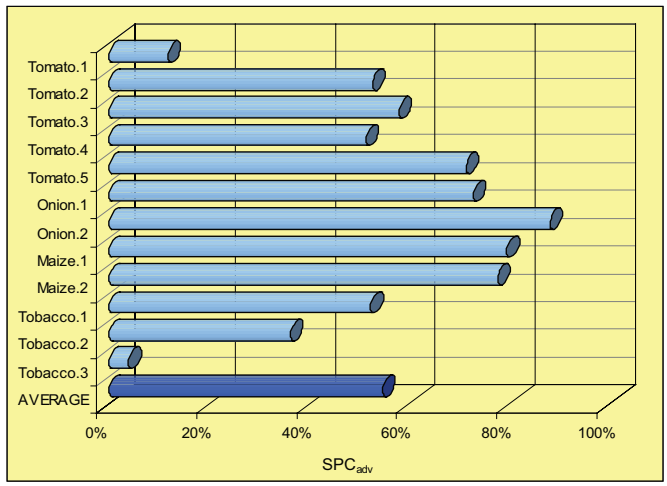

Fig. 3. Advantage of sprinkler on specific irrigation cost (Avantage de l'irrigation par aspersion sur les coûts spécifiques de l'irrigation par parcelle)

Composition of specific irrigation cost (SPC) is very different. Energy is the main cost of hose reel irrigation, amounting to about 55% of the SPC. Purchasing and disposal of drip lines is about the half of the drip SPC (51.1%). Arrangement of sprinkler and drip SPC is given in Figure 4.

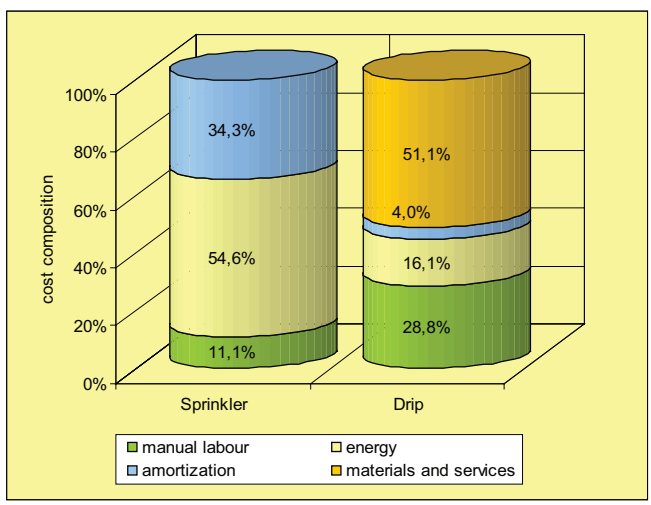

Fig. 4. Average composition of specific irrigation cost (Composition moyenne des coûts spécifiques de l'irrigation)

3.3. Productivity

Comparison of production performance allowed by irrigation can be made according to income. For each case study, Figure 5 shows the difference between incomes as advantage of sprinkler irrigation, represented by the ID index. In some cases (i.e., Tomatoes) ID depends primarily on the difference between the GI under drip and sprinkler supply. The ID advantage of sprinkler irrigation is given by lower IC, compensating for lower GI in some cases. Better ID is provided by sprinkler irrigation in 8 cases out of 12.

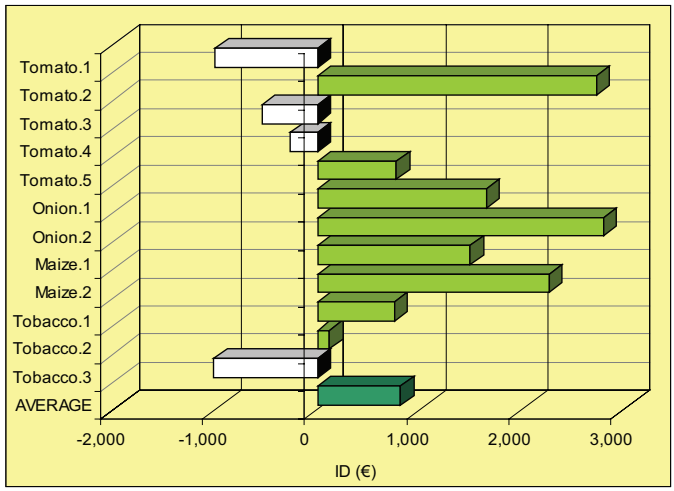

Fig. 5. Income difference of individual case study (Différence de revenu de chaque cas d'étude)

The influence of drip and sprinkler irrigation on AR is illustrated in Figure 6. Average advantage of sprinkler supply is 75%, individual values range from -24% to 420%.

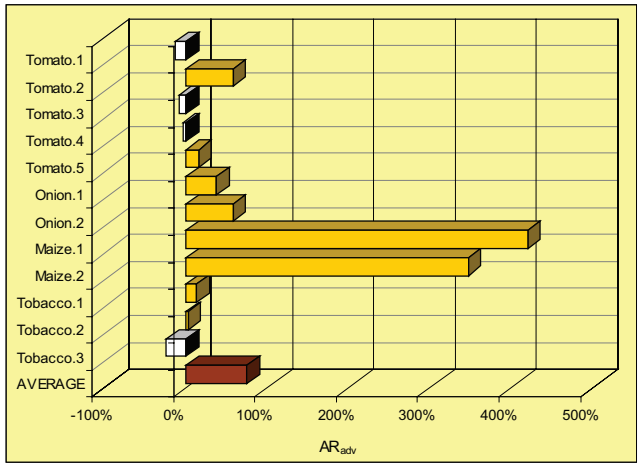

Fig. 6. Advantage of sprinkler on available resources (Avantage de l'irrigation par aspersion par rapport aux ressources disponibles)

The comparison in terms of available resources for the other production factors (AR) can be interpreted as an improved ability of sprinkler irrigation in enhancing their contribution to the overall result, regardless of the specific techno-economic characteristics of individual crops.

3.4. Water use

Assessment of irrigation management is allowed by the RS index, which provides for a comprehensive evaluation accounting for irrigation equipment performance and farmer's professional skills. For each case study, comparison between hose reel sprinkler and drip RS is given by a pair of values, as shown in Figure 7. In four cases, irrigation was carried out according to the calculation of net requirements and therefore the surplus is nil. In 7 of the remaining 8 cases, surplus occurred and was always lower under sprinkler irrigation. This would show an easier management allowed by sprinkler with respect to drip irrigation.

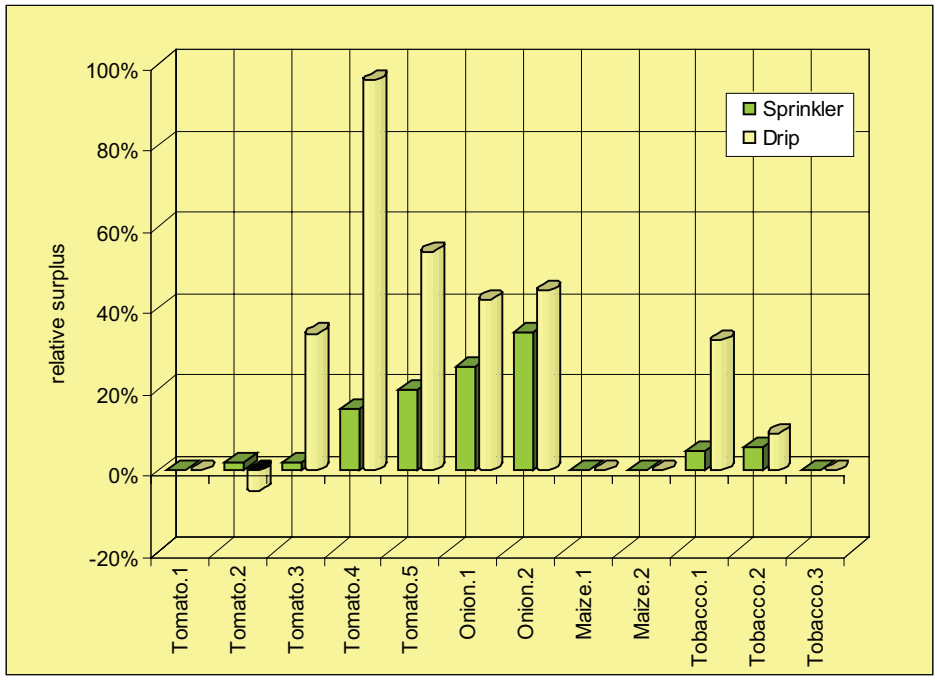

Fig. 7. Relative surplus of supplied water (Surplus relative à l'eau fournie)

Water supplied on seasonal basis is given in Figure 8 by the SIS_{adv} index, which is positive in most cases (9 out of 12). Hose reel sprinkler supply seems to be more suitable to water saving, but SIS_{adv} should be compared with the RS index since surplus depends on the method features and management.

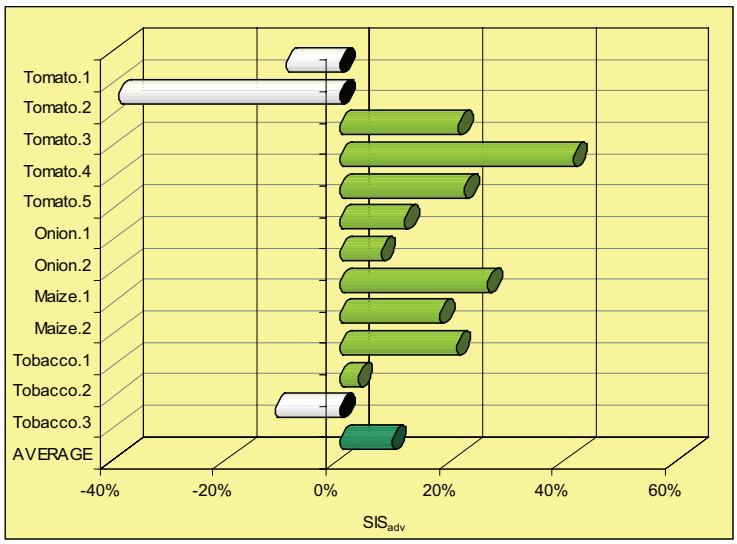

Fig. 8. Advantage of sprinkler on seasonal irrigation supply (Avantage de l'irrigation par aspersion sur les volumes saisonniers d'irrigation)

Sprinkler agronomic efficiency (GI_{EFN}) is almost always greater (9 times out of 12), by about 15% on average, the values ranging from -30% to 52% (Fig. 8). According to the index GI_{EFNadv}, irrigation productivity, given as GI, seems more positively related to sprinkler than drip irrigation. Watering by sprinklers has always been less expensive, averaging about 50% less than the drip, with a minimum of 14% and a maximum of 87% (Fig. 9). It is noted that a more rational use of water would level down the benefits of sprinkler over drip irrigation by reducing the RS difference between them. Due to the high incidence of energy, decline in cost of sprinkler water supply would be the consequence.

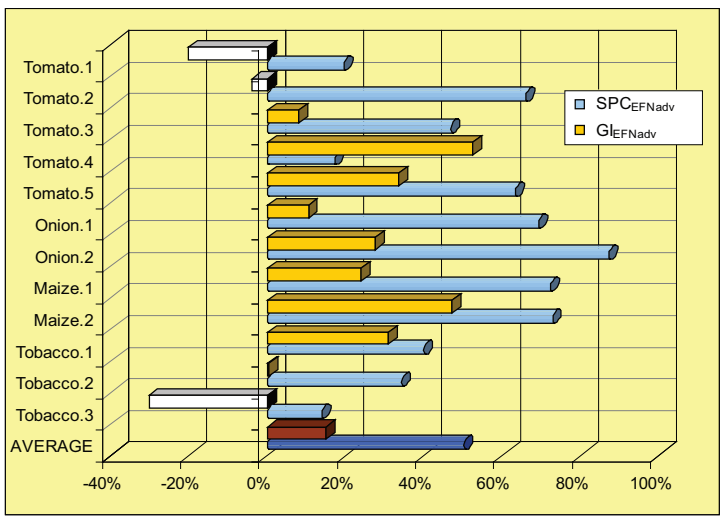

Fig. 9. Advantage of sprinkler on agronomic (GI_{EFNadv}) and economic (SPC_{EFNadv}) efficiency (Avantage de l'irrigation par aspersion sur le efficience agronomique et économique)

The combination of the above effects in the two irrigation methods is summarized by the economic effectiveness (AR_{EFC}) which indicates ability to enhance the economic value of water used (Figure 10).

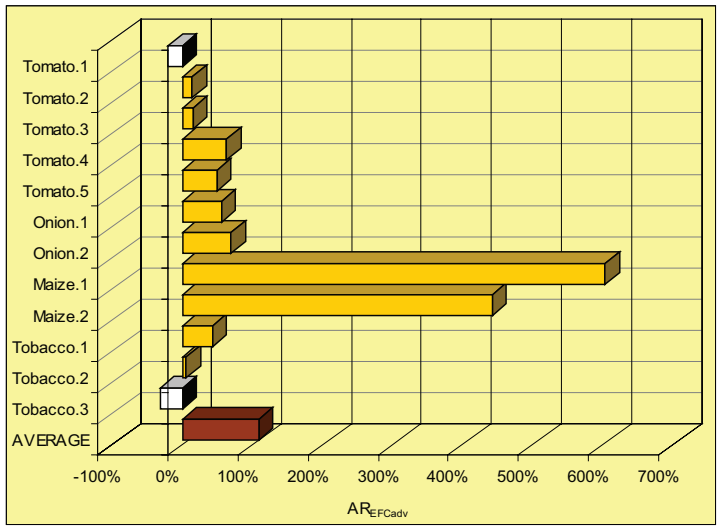

Fig. 10. Advantage of sprinkler on economic effectiveness (AR_{EFC}) (Avantage de l'irrigation par aspersion sur l'efficacité économique)

The AR_{EFC} yielded by hose reel sprinkler irrigation is better in most cases (10 out of 12), from a minimum of -32% to a maximum of more than 600% and an average of 108%. From the economical point of view, the productivity of irrigation water under hose reel sprinkler supply was at least twice than under drip irrigation.

3.5. The choices of farmers

The economic analysis carried out in the cases studied, shows that sprinkler hose reel irrigation is more convenient than drip irrigation. However, this does not provide a final assessment, both for the limited extent and nature of the sample, and especially since the choice of irrigation method is established according to farmer's specific needs in some cases. Field experience and opinions of farmers stress the importance represented by the overall farm characteristics (i.e., locations of farmland, size and shape of the fields, labour availability and cost). Examples can depict actual circumstances during which the use of the reel machines can be critical, such as the time needed for shifting and placement may exceed the labour capacity during some period of the cropping season; small size, irregular-shaped fields and windy conditions make it difficult the use of mechanized sprinkler irrigation. Furthermore, fertigation is currently regarded as easier with drip supply, this opinion being supported by inadequate information in respect of the possibilities offered by recent technological development of the reel machines. Farmland arrangement affects the working capacity of the hose reel machines, which ranges from 5 to 36 hectares in the farms examined, that is about 17 ha on average (44% of the potential). In spite of this, the use of reels machines is still more convenient than the dripline, showing their profitability also when used under sub optimal working conditions and in spite of the amortization cost.

4. CONCLUSIONS AND RECOMMENDATIONS

The different production responses are expected to depend on three main reasons: different effectiveness of drip and hose reel sprinkler irrigation under the particular farming conditions of the individual cases examined (i.e., combinations of soil and climatic conditions), different effectiveness of production techniques between farms and crops, differences between crops within the same context. The limited scope of the sample, and the variables influencing the results, do not enable final assessments. With respect to the cases observed, crop yields under different irrigation types are equivalent, but lower costs are allowed by hose reel sprinkler supply, which contributed to the achievement of better economic performance. Furthermore, water use under sprinkler irrigation was generally better in terms of both seasonal water supply and relative surplus. Conversely, operational limits of hose reel irrigation were detected at farm level under particular environmental and farmland characteristics. These conditions account for the spread of drip irrigation in the study areas. In practice, both methods have advantages and disadvantages, and each can be more or less suitable and convenient, depending on the specific characteristics of crop, environment and farm. Both sprinkler and drip systems are used often in the same farm, during the same season and on the same crop, playing a complementary role in the actual farming system. The question is not to establish which of the two methods is to be preferred, but to decide on what is the most suitable combination of them at farm level, taking also into account the need for more information and better technical training for farmers.

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Annex 1. Production, income and cost composition of each case study (Production, revenu et composition du coût pour chaque cas d'étude)

Item		Irrigation type	Tomato n. 1	Tomato n. 2	Tomato n. 3	Tomato n. 4	Tomato n. 5	Onion n. 1	Onion n. 2	Maize n. 1	Maize n. 2	Tobacco n. 1	Tobacco n. 2	Tobacco n. 3	Average
Marketable production	t/ha	Sprinkler	105,3	89,2	64,0	67,5	75,0	50,0	46,3	57,3	85,2	3,9	3,4	2,1	-
		Drip	112,4	78,0	68,5	76,5	75,0	51,1	39,6	62,6	70,3	3,8	3,5	2,7	
Average price	€/t	Sprinkler	73,5	90,6	93,2	99,5	78,2	135,0	170,6	40,0	40,0	1750,0	1700,0	1700,0	-
		Drip	78,8	77,5	101,8	98,0	75,1	135,0	168,5	40,0	40,0	1750,0	1700,0	1700,0	
Gross income	€/ha	Sprinkler	7739,6	8077,1	5956,9	6716,3	5865,0	6750,0	7891,5	2292,0	3408,0	6825,0	5763,0	3621,0	-
		Drip	8851,5	6041,1	6973,3	7497,0	5631,0	6898,5	6665,5	2504,0	2812,0	6562,5	5933,0	4658,0	
Cost of manual labour	€/ha	Sprinkler	270,0	7,2	25,2	34,8	3,6	43,2	19,2	57,6	64,8	42,0	22,8	118,8	11,1%
Cost of energy			523,9	426,2	151,8	288,1	125,8	555,0	131,6	159,8	194,8	258,8	171,2	220,4	54,6%
Cost of amortization			72,0	194,0	167,9	167,9	87,9	77,2	64,0	224,8	224,8	148,6	296,6	72,0	34,3%
Total cost			865,9	627,4	344,9	490,8	217,3	675,4	214,8	442,2	484,4	449,3	490,6	411,2	100,0%
Cost of manual labour	€/ha	Drip	291,6	642,0	184,8	192,0	80,4	795,6	710,4	958,8	932,4	201,6	103,2	85,2	28,8%
Cost of energy			430,7	133,2	71,5	246,4	181,2	693,8	95,1	78,6	114,1	160,1	86,9	50,3	16,1%
Cost of materials and services			242,7	507,2	478,1	485,0	396,1	968,2	968,2	1088,4	1088,4	559,0	559,0	276,3	51,1%
Cost of amortization			15,8	39,4	83,9	83,9	98,6	15,6	15,6	22,7	22,7	19,7	19,7	15,8	4,0%
Total cost			980,8	1321,8	818,3	1007,3	756,3	2473,2	1789,3	2148,4	2157,6	940,5	768,8	427,6	100,0%

Annex 2. Economical and technical parameters of individual case study
(Paramètres économiques et techniques pour chaque cas d'étude)

Parameters and indexes		Irrigation type	Tomato n. 1	Tomato n. 2	Tomato n. 3	Tomato n. 4	Tomato n. 5	Onion n. 1	Onion n. 2	Maize n. 1	Maize n. 2	Tobacco n. 1	Tobacco n. 2	Tobacco n. 3	Average
Gross Income (GI)	€/ha	Sprinkler	7739,6	8076,9	5956,5	6716,3	5865,0	6750,0	7891,3	2292,0	3408,0	6825,0	5768,1	3620,1	
		Drip	8851,5	6040,9	6973,0	7497,0	5631,0	6898,5	6665,3	2504,0	2812,0	6562,5	5929,6	4649,6	
Advantage GI (GIadv)	%	-	*-12,6*	*33,7*	*-14,6*	*-10,4*	*4,2*	*-2,2*	*18,4*	*-8,5*	*21,2*	*4,0*	*-2,7*	*-22,1*	*0,7*
Specific Plot Costs (SPC)	€/ha	Sprinkler	865,9	627,4	344,9	490,8	217,3	675,4	214,8	442,2	484,4	449,3	490,6	411,2	
		Drip	980,8	1321,8	818,3	1007,3	756,3	2473,2	1789,3	2148,4	2157,6	940,5	768,8	427,6	
Advantage SPC (SPCadv)	%	-	*11,7*	*52,5*	*57,9*	*51,3*	*71,3*	*72,7*	*88,0*	*79,4*	*77,6*	*52,2*	*36,2*	*3,8*	*54,5*
Aavailable Resources (AR)	€/ha	Sprinkler	6873,7	7449,4	5611,6	6225,5	5647,8	6074,6	7676,5	1849,8	2923,6	6375,7	5277,5	3209,0	
		Drip	7870,8	4719,1	6154,7	6489,8	4874,7	4425,3	4876,0	355,6	654,4	5622,0	5160,8	4222,0	
Advantage AR (ARadv)	%	-	*-12,7*	*57,9*	*-8,8*	*-4,1*	*15,9*	*37,3*	*57,4*	*420,2*	*346,8*	*13,4*	*2,3*	*-24,0*	*75,1*
Income Difference (ID)	€/ha	-	-997,1	2730,3	-543,1	-264,3	773,1	1649,3	2800,5	1494,3	2269,2	753,6	116,7	-1013,1	
Advantage ID (IDadv)	%	-	*-11,3*	*45,2*	*-7,8*	*-3,5*	*13,7*	*23,9*	*42,0*	*59,7*	*80,7*	*11,5*	*2,0*	*-21,8*	*19,5*
Seasonal Irrigation Supply (SIS)	m^3/ha	Sprinkler	2273	1600	1940	1200	1334	2682	2237	1020	700	1890	1250	1890	
		Drip	2072	1150	2450	2040	1710	3027	2410	1380	850	2378	1290	1693	
Advantage SIS (SISadv)	%	-	*-9,7*	*-39,1*	*20,8*	*41,2*	*22,0*	*11,4*	*7,2*	*26,1*	*17,6*	*20,5*	*3,1*	*-11,6*	*9,1*
Agronomic Efficiency (GIefn)	$€/m^3$	Sprinkler	3,4	5,1	3,1	5,6	4,4	2,5	3,5	2,3	4,9	3,6	4,6	1,9	
		Drip	4,3	5,3	2,9	3,7	3,3	2,3	2,8	1,8	3,3	2,8	4,6	2,8	
Advantage GIefn (GIefnadv)	%	-	*-20,1*	*-3,8*	*7,7*	*52,2*	*33,7*	*10,5*	*27,4*	*24,3*	*47,1*	*30,8*	*0,2*	*-30,2*	*15,0*
Economic Efficiency (SPCefn)	$€/m^3$	Sprinkler	0,4	0,4	0,2	0,4	0,2	0,3	0,1	0,4	0,7	0,2	0,4	0,2	
		Drip	0,5	1,2	0,3	0,5	0,4	0,8	0,7	1,6	2,5	0,4	0,6	0,3	
Advantage SPCefn (SPCefnadv	%	-	*19,1*	*66,1*	*45,5*	*16,3*	*63,6*	*69,5*	*86,5*	*72,4*	*72,8*	*40,0*	*35,0*	*12,0*	*50,1*
Economic Effectiveness (ARefc)	$€/m^3$	Sprinkler	3,0	4,7	2,9	5,2	4,2	2,3	3,4	1,8	4,2	3,4	4,2	1,7	
		Drip	3,8	4,1	2,5	3,2	2,9	1,5	2,0	0,3	0,8	2,4	4,0	2,5	
Advantage ARefc (ARefcadv)	%	-	*-20,5*	*13,7*	*15,1*	*63,2*	*48,4*	*54,8*	*69,8*	*596,2*	*442,9*	*42,8*	*5,5*	*-31,7*	*108,9*
Net Irrigation Requirement (NIR)	m^3/ha	Sprinkler	2270	1570	1900	1040	1110	2130	1670	1020	700	1800	1180	1890	
		Drip	2070	1210	1830	1040	1110	2130	1670	1380	850	1800	1180	1690	
Relative Surplus (RS)	%	Sprinkler	0,0	1,9	2,1	15,4	19,8	25,8	34,1	0,0	0,0	5,0	5,9	0,0	
		Drip	0,0	-5,0	33,9	96,2	54,1	42,3	44,3	0,0	0,0	32,2	9,3	0,0	