THE ENERGY BALANCE OF SUNFLOWER (Helianthus annuus L.) IN SEMI-ARID CONDITIONS UNDER DIFFERENT CULTURE CONDITONS.

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Summmary

The productivity and energy balance of sunflower in a semi-arid Mediterranean area is studied under three different culture systems in order to determine energy efficiency under hydric stress. The traditional dry farming system, in spite of being scarcely productive in terms of marketable biomass only represents 10% of that obtained in irrigation farming and 30% of that obtained in rational dry farming. The most energy-efficient system is rational dry farming.

Key words: Sunflower, Helianthus, energy-balance, hydric-stress.

Introduction

Today sunflower, along with olive, is the most important source of edible oil in Spain, and figures in fourth place when considered at world level (FAO, 1992).

In Spain, it occupies an area of around one million hectares and stands as third herbaceous crop under this criterion; most of this area is farmed on dryland, under a Mediterranean climate, where rainfall is mainly in Autumn and Spring. Grain production is low, varying between 500 and 1.500 kg/ha, which reflects sever hydric limitations for productivity.

Lower productivity corresponds to that part of the area enclaved in semi-arid zones, with annual rainfall of around 400 mm., and such a high evapo-transpiration, that the sunflower must withstand very difficult hydric conditions, which is the factor that most affects its productivity. At times it shows such a rigorous drop in output, that its energy and economic profitability may be considered doubtul.

Considering that fossile energy resources are limited, the evaluation from an energy point of view of the productivity of a crop in different zones and under different production systems, is a demand that is raised, to know the real potentiality of any farming business. The semi-arid areas where it is not feasible to obtain high output, due to their peculiar rainfall system, purports priority interest for this kind of work.

The present study discusses an energy and economic balance for sunflower crop under dryland conditions, in a low rainfall area ($P < 400$ mm/year), using a rational tecnique designed to improve the use of available water; comparing it with another two obtained in irrigable land conditions and using the traditional crop system for dryland, performed in semi-arid zones of the Central Meseta, in the Iberian Peninsula.

Material and methods

To assess the productive potential of sunflower under dryland and irrigated land conditions, a test was performed in rabdom blocks with four replications and a elementary plot of 24 m^2 in the province of Toledo.

The soil analysis shows a very low content of organic matter, pH (1:2 H_2O) of 7,60, and the textura (USDA) franco-silty.

The climatic type of the location corresponds to the Continental Mediterranean, in accordance with the classification of PAPADAKIS (1966). The rainfall registered in one year was 415 mm and the evapotranspiration estimated by the method of Thornhwaite was 744 mm.

On the irrigated land plots, the soil was maintained at field capacity below 30 cm in depth, under the necesary irrigation, using pumping engine and water from the Tajo river with an offlevel of 4 m.

The density of plants and crop care were the usual ones for every kind of cultivation, save the fact that on rational dryland several techniques were carried out designed to take better advantage of the soil water and increase fertility. In all the cases cultivar hybrid SH-25 was used; a density of 50.000 plants/ha for both dryland conditions and 89.000 plants/ha for irrigation land.

The soil was prepared with moulboard plow of 40 cm depth, performed in the mont of November for the rational dryland system, and in February for the traditional dryland and irrigation systems and later gone over with tiller to prepare the bed for sowing. This was carried out on the the 25th March, a normal time for that region.

Any type of fertilization was used on traditional dryland system whilst for rational dryland 1.500 kg/ha were used of compound 8-24-8, and on irrigation system was applied a dosage of 500 kg/ha mixed with a soil insectide (3 kg/ha), and as a coverage fertilizer 250 kg/ha of calcium ammonia nitrate (26% N).

On rational dryland weeds were controlled by a first wide shovel tiller, and a second with a ridge tiller. On traditional dryland only the first mechanical work was used and on irrigated land Trifluralin 0,9 l(m.a.)/ha and identical mechanical work to traditional dryland system.

Harvesting took place on the 20th of September using a self propeller combine harvester for trials, and transport using tractor and trailer. The whole of the aerial part and the grain produced were harvested.

Fuel conversion (gasoil B) and other inputs to energy units was performed using the methodology proposed by FERNANDEZ-GONZALEZ (1982). Not only inputs deriving from the mechanical work and raw materials were considered, but also those correspoding to manpower (6 Mcal/h).

Results and discussion

Productivity obtained in the experiment and survey carried out are compiled in table 1, taking off in marketable, harvestable biomass. The greast production of biomass that can harvested corresponds to sunflower grown on irrigated land, which is three times the correspondig to rational dryland system. The low output obtained in traditional dryland is also in the order of three times inferior to those corresponding to rational dryland, where techniques have been used which improve the fertility and efficieny use of water by the plant. This shows that the low output of traditional dryland is at least partly influenced by routine and hardly suitable farming practices, and not only by the difference in precipitation and evapotranspiration. On the other hand, the difference between both systems does not represent a high economic cost, and is basically due to four points:

a) Early performance of mouldboard plow work.
b) Use of a maintenance fertilizer.
c) Extension of the tiller work.
d) Efficient weed control.

The harvest index is more favourable in the irrigated land system. On the other hand, the one corresponding to traditional dryland is the smallest, which perhaps be interpreted in basis on an increase in the area of non fruiting head, which occurs as consequence of a higher water stress.

Direct energy used in traditional dryland, is based on data used in the rational dryland system, eliminating the non-used production components, reach a total of 561,0 Mcal/ha. This important saving energy which corresponds to approximtely half of the total energy used in the rational dryland system, is fundamentally explained by the absence of the base fertilizer, since it represents 457 Mcal/ha, considering also its distribution, which is almost the total of the other components. On the other hand, the energy invested in manpower is quite similar for the two dryland systems.

Table 1.- Productivity in terms of dry matter of sunflower (Helianthus annuus L.), under different crops systems in the province of Toledo (Spain).

Crop system	Biomass (kg/ha)		Harvest index
	Harvestable	Marketable	
Irrigated land	12.353 a	3.908 a	0,32
Rational dryland	4.420 b	1.350 b	0,31
Traditional dryland	1.400 c	391 c	0,28

The values with different letters are significant at level of 1%.

Table 2.- Input-output for the sunflower under three crop systems in Toledo Province (Spain).

Crop system	Input (Mcal/ha)	Output (Mcal/ha)		Output/input		Output-input (Mcal/ha)	
		Harvestable Biomass	Marketable Biomass	Harvestable Biomass	Marketable Biomass	Harvestable Biomass	Marketable Biomass
Irrigation	3.828	59.233	27.004	15,47	7,05	55.405	23.176
Rational dryland	1.079	21.194	9.329	19,64	8,65	20.115	8.250
Traditional dryland	561	6.713	2.702	11,97	4,81	6.152	2.141

1 cal = 4,186 julios

In the irrigated land crop, total input used is about three times higher compared with that used in rational dryland and six times higher that in traditional dryland. Output obtained in this system is without doubt much higher than in any of the other two, but considering the high levels of its energy input, a detail analysis must be made to know the efficiency levels of the differents systems. Table 2 shows the input and the inputs and some index related. When index "output/input" is compared for the three crop systems in terms of marketable biomass, the most efficient one in the use of energy is rational dryland, which almost doubles the efficiency of traditional dryland, whilst irrigated land is similar to the first one. However the irrigation land system is the one which has the largest production of total and marketable biomass.

Photosyntetic efficiency is highger in irrigated land than other systems, which are linked with the biomass produced.

Despite its limited production of marketable biomass, traditional dryland has a positive energy balance "output-input". It is also positive when the balance is considered, from a strictly economic point of view.

The traditional dryland system is not very productive in terms of energy, but does use large input levels. Its use can only be carried out in zones where are large areas, because the marketable biomass obtained in 10 ha is only equivalent to 1 ha under irrigated system. The choice of the production method should be made regionally, because none of the methods get the maximum in all parameters, and also it is important to consider socila-economic indicators.

Conclusions

1. The traditional dryland system, in semi-arid Mediterranean zones produces very low outputs, but however it has a positive energy balance.

2. The most efficient system in the use of energy is the rational dryland one.

3. The irrigated land system is very efficient, considering the energy balance and phytosynthetic efficiency, but not so when the efficient of energy use is considered.

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