CALCULATION OF THE REMUNERATIVENESS OF SPRINKLER IRRIGATION

C. BAARS

(Proefstation voor de Akker- en Weidebouw, Wageningen, Nederland)

Up to now much attention has been paid to the research concerning the most favourable water supply. However, there is still a great lack in our knowledge of the remunerativeness of supplemental irrigation and only few investigations have been made on this part of the problem.

Ultimately the farmer wants to reach better financial results by means of sprinkling. When he intends to change over to sprinkler irrigation, he will make inquiries about its remunerativeness. It is not sufficient to tell him how much the increase in yield per crop, the water requirements of the crops and the costs of water per mm. per ha. will be. The relation of costs and returns is not so simple at all, for as a consequence of sprinkler irrigation the whole management changes and must of necessity change if sprinkler irrigation will be remunerative.

On dry soils mainly cereals are grown. It is well-known that in Western Europe only little profits can be made by sprinkling cereals. For a remunerative application of sprinkler irrigation it is necessary to change over to a more intensive management. The cereals have to be partly replaced by root crops, leguminous plants, grassland and eventually vegetables. As a consequence the gross income of the farm rises considerably but at the same time the expenses and the labour requirements go up. When we place the value of the increase in production against its costs, the difference will be the remunerativeness of the irrigation. Both the increase of returns and its costs are influenced by various factors, which are different for each farm.

If it is desired to know beforehand the remunerativeness of sprinkler irrigation for a certain farm, it is necessary to make an estimate, taking into account the particular circumstances of the farm such as available labourers, available capital, knowledge and interest of the farmer, waterholding capacity of the soil, parcelling, available buildings and machinery, etc.

In non-agricultural business economic planning is a standing procedure; for small farms it is not. There it is customary to rely on intuition, but if a drastic measure like irrigation is introduced without thorough preparation, the best result is never reached.

For drawing up an estimation of the remunerativeness a number of data are required, such as labour norms, manuring norms, feeding norms, production norms for irrigated crops, norms for the need of irrigation, etc. Specific norms for sprinkler irrigation are not available. In the Netherlands these norms are gathered on 15 experimental farms for sprinkler irrigation, among which are 2 co-operative farms. They are situated on various soils. Here the average yields of irrigated crops, the average need of irrigation and the need of labour for sprinkling under practical farming conditions are determined. With the

help of these norms estimates can be drawn up of the remunerativeness of sprinkler irrigation for other farmers intending to change over to sprinkling. In this way the farmer in question is informed about the profit that sprinkler irrigation of his farm may give, but at the same time he will notice how the farm management should change, how much should be invested and how much the labour requirements will increase.

With the help of an example we shall now consider the various constituent parts of the estimate of remunerativeness of sprinkler irrigation.

1. Estimate of the increase in income

In table 1 the value of the increase in yield in consequence of sprinkler irrigation has been calculated. On the debit side the yields of the non-irrigated farm occur, on the credit side those of the irrigated farm. For the non-irrigated farm we take the usual cropping scheme and the average yields which were really reached. Another method of calculation is only applied if it is evident that considerably higher yields could have been reached under existing conditions. For the yields of the irrigated farm we take the norms based on the yields obtained on well-managed experimental farms for sprinkler irrigation.

In drawing up the cropping scheme for the irrigated farm, one generally starts with grassland and fodder crops. Therefore it is necessary to establish first the desirable number of cattle. As a rule the available stable room is the limiting factor. Such a number of grass and fodder crops must be included in the cropping scheme that the fodder requirements of the cattle can be met. The remaining soil is available for the culture of cash crops. In drawing up a cropping scheme for the last mentioned crops, not only the financial profit should be considered but also the crop rotation and the labour requirements.

The yield of cash crops is evaluated at the mean market prices of the last few years. The grass and the fodder crops are evaluated on the basis of animal products, viz. the milk yield and the live-weight increase of the cattle. The milk yield per cow can be estimated higher for the irrigated farm only, if it is sure that without irrigation every year a considerable depression in milk yield occurred as a consequence of dryness. For the live-weight increase of the cattle a fixed norm is used.

2. Estimate of the costs of increase in yield

Against the increase in the value of the yield are many extra expenses.

a. Operating costs of the sprinkler installation

Before drawing up a calculation of the operating costs of the sprinkler installation, it is necessary to make a scheme including an estimate for the irrigation equipment; only then the most important costs, as depreciation and interest, can be figured. For the fixed main lines and the pumping unit the depreciation may be spread over 20 years, for the portable laterals with sprinklers over 10 years. As a consequence of the depreciation the interest must be calculated on an average of 55 % of the invested capital.

In order to be able to calculate the cost of electricity or fuel, it is necessary to know at first the average annual time of application. From the observations on the experimental farms for sprinkler irrigation, norms have been drawn up for the average need for irrigation of the various crops on soils with different

TABLE 1. Calculation of the value of the increase in yield by means of sprinkling 10 ha of the total of 11.44 ha; in Dutch guilders

Without sprinkling		With sprinkling	
2.5 ha rye (2200 kg/ha; f 0.24 per kg)	f 1320	2.0 ha rye (2750 kg/ha; f 0.24 per ha)	f 1320
straw (4500 kg/ha; f 50 per 1000 kg)	- 563	straw (5000 kg/ha; f 50 per 1000 kg)	- 500
2.3 ha oats with barley (2200 kg/ha; f 0.25 per kg)	- 1265	1.0 ha oats with barley (3000 kg/ha; f 0.25 per kg)	- 750
straw (3500 kg/ha; f 30 per 1000 kg)	- 242	straw (4000 kg/ha; f 30 per 1000 kg)	- 120
1.0 ha potatoes (20000 kg/ha; f 50 per 1000 kg)	- 1000	0.5 ha early potatoes (15000 kg/ha; f 0.12 per kg)	- 900
0.5 ha peas (2300 kg/ha; f 0.40 per kg)	- 460	0.5 ha table stock potatoes (30000 kg/ha; f 0.05 per kg)	- 750
straw (2500 kg/ha)		0.35 ha sugar beet (40000 kg/ha; f 50 per 1000 kg)	- 700
0.3 ha fodder beet (55000 kg/ha)		0.5 ha peas (2750 kg/ha; f 0.40 per kg)	- 550
0.6 ha red clover (6000 kg hay per ha) } for cattle [1]		0.65 ha fodder beet (75000 kg/ha)	
0.1 ha carrots		(0.35) ha sugar beet tops with leaves (40000 kg/ha)	
(1.5) ha stubble turnips		(0.5) ha pea straw (3000 kg/ha)	
4.14 ha grassland		(0.2) ha stubble turnips } for cattle [2]	
milk 7 × 4000 kg; f 0.27 per kg	- 7560	(1.0) ha Westerwolth rye grass	
increase in live-weight 7 × f 250	- 1750	4.5 ha ley (sprinkled)	
money earned by supplying pasture for 4 head of young cattle	- 400	1.44 ha permanent pasture (not sprinkled)	
		milk 11 × 4400 kg; f 0.27 per kg	- 13068
gross increase in income by sprinkling	- 6848	increase in live-weight 11 × f 250	- 2750
	f 21408		f 21408

[1]) 7 milk cows
2 head of young cattle, 1 to 2 years old
3 head of young cattle, less than 1 year old

[2]) 11 milk cows
4 head of young cattle, 1 to 2 years old
4 head of young cattle, less than 1 year old

TABLE 2. Estimate of total labour requirements of the farm with sprinkling; in manhours

Labour for	Hectares or number	Hours per unit	Jan.	Febr.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rye	2.—	86	–	–	12	8	8	–	40	52	–	32	–	20	172
Oats with barley	1.—	86	–	–	20	–	10	–	6	30	10	–	–	10	86
Peas	0.50	216	–	–	4	12	25	4	34	25	–	–	–	4	108
Potatoes	1.—	412	–	–	–	56	26	40	10	–	140	40	–	100	412
Fodder beet	0.65	456	–	–	10	16	140	90	–	–	–	120	80	–	456
Sugar beet	0.35														
Turnips (stubble crop)	2.—	130	–	–	–	–	–	–	60	–	–	–	140	60	260
Westerwolth rye grass (stubble crop)	(1.—)														
Ley	(4.50)														
Permanent pasture (not sprinkled)	(1.44)														
Care of the grassland	5.94	50	–	–	18	30	36	48	60	60	30	18	6	–	306
Haymaking	18 × 1000 kg	16						160	70	58					288
Silage making	38 × 1000 kg	4					80					72			152
Dung dressing	100 × 1000 kg	1.5		100	50										150
Milking and care of the milk cows and their calves	11	216	220	220	220	220	176	176	176	176	176	176	220	220	2376
Porkers (average)	40		90	90	90	90	90	90	90	90	90	90	90	90	1080
Chickens (average)	200														
Soil cultivation					60	20				20				40	140
Total, excluding sprinkling			310	410	484	452	591	608	546	511	446	548	536	544	5986
Sprinkling (maximum)							120	120	95	95					430
Total including sprinkling (maximum)			310	410	484	452	711	728	641	606	446	548	536	544	6416
Available (2 men)			528	528	528	528	616	616	616	616	616	616	528	528	6864
Shortage of labour (maximum)							95	112	25				8	16	256

waterholding capacity. With the aid of these norms and the cropping scheme we can calculate the average annual water demand. As the pump capacity is known, the number of operating hours per year can be found and from this the cost of electricity or fuel may be calculated.

The labour necessary for operating the equipment consists mainly of moving the sprinkler lines. We suppose that a modern plant is used with a permanent main and portable lateral lines with rotary sprinklers. If it is known how many metres of pipe should be moved on an average per position (L), how many metres of pipe one man can move as an average per hour (f) and the number of times that the sprinkler line must be moved on the average per year, then the number of man hours can be calculated.

The number of times that the pipes must be moved on the average, can be calculated by dividing the average annual need for irrigation of the farm in litres (B) by the quantity that is given per position. This quantity can be found by multiplying the area in m.^{2} (O) by the application per position in mm. (d).

$$\text{Labour requirements} = \frac{L \times B}{f \times O \times d}$$

The area O can be calculated from the number and the spacing of the sprinklers. The application per position is also known; this is mostly 20 to 30 mm. The factor f, the length of sprinkler line in metres that one man can move per hour, is to be fixed on 150 for galvanized iron pipes of ⌀ 60 and 70 mm. and on 200 for aluminium pipes ⌀ 60 and 76 mm. These norms have been found on the experimental farms for sprinkler irrigation. In table 3 on the credit-side the cost of operating the sprinkler irrigation plant can be found.

TABLE 3. Estimate of the remunerativeness of sprinkling

Gross increase in income (see table 1)	f 6848	Direct costs and labour requirements of sprinkling:	
		a. interest and depreciation	f 900
		b. electricity	- 340
		c. labour requirements of sprinkling 223 man hours [1])	
		extra labour needed for the new cropping scheme 1215 man hours [1])	
		extra costs of fertilizers	- 530
		extra costs of seed	- 150
		extra costs of concentrates and litter for extra cattle 4 × f 250	- 1000
		other extra costs	- 735
		net increase in income	- 3193
	f 6848		f 6848

[1]) In this case the extra labour (1438 man hours) could be done by the two men available, so extra expenses were not necessary.

b. Extra costs of fertilizers

In consequence of the modification in the cropping scheme the consumption of fertilizers changes too. From the old and future cropping scheme and with the aid of the usual manuring norms, the extra costs of manuring can be calculated. In table 3 these costs have been stated on the credit-side.

c. Extra costs of seed

In consequence of the modification of the cropping scheme the costs of seed also change.

The calculation of this modification needs no further explanation. The extra costs are stated in table 3.

d. Extra costs of concentrates and litter for the cattle

In the new cropping scheme sufficient fodder for the cattle has to be planned. However, the extra milk cows need concentrates and litter too. For this a fixed norm per milk cow can be taken. The extra costs are included in table 3.

e. Various extra costs

These are: the increase of interest and depreciation, of the expenses for maintenance, insurance, etc., in consequence of the expansion of buildings, inventory and cattle. This item is often rather high. The extra costs have been stated in table 3. The investments in question have been mentioned in table 4.

f. Extra costs of labour

The labour required for operating the sprinkler system has already been considered.

In consequence of the intensification, the labour requirements of the whole farm do increase. For calculating the labour requirements we can take the usual norms of labour. From the cropping scheme and the stock of cattle of the old and new farm, the increase in labour requirements can be calculated. However in order to gain a better insight into the increase in the labour requirements and its costs, it is desirable to make a plan for the labour requirements per month of the whole irrigated farm, inclusive the sprinkler irrigation. The available supply of labour is included. From the plan it is seen in which months there is a shortage of labourers. If sufficient seasonal labourers can be found the calculation of the extra costs of labour is not difficult. In most cases, however, seasonal labour cannot be found, a permanent labourer must be employed and should be employed fully. Therefore it is important that the labour is spread favourably over the year and that the occurence of peak periods is prevented when drawing up the cropping scheme. Peak periods can be smoothed out by mechanization and finally it is possible to use in this period a contractor.

In our example the labour requirements have increased considerably in consequence of the irrigation. In summer the labour requirements are higher than the supply of labour of two adult men, especially when there should be sprinkled to a large extent. As in this period the farmer's wife can assist, if necessary, no extra labourer will be needed. In this case full employment is reached by the irrigation.

In table 2 the data about labour requirements and supply of labour of the irrigated farm are given.

In table 3 the increase in income and its costs of production have been given. In the mentioned case the family income can increase considerably by means of sprinkler irrigation.

3. Estimate of the investments

It is not only important that the farmer is informed about the remunerativeness of sprinkler irrigation; he also ought to know how much must be invested. Besides the cost of purchase of the irrigation equipment, large investments are necessary for the buying of extra cattle, for enlarging buildings and for the purchasing of extra machinery. Without these investments sprinkling will be less remunerative; but as a rule the farmer will highly undervaluate these.

In table 4 the estimate of the investments is given. In this case the total amount is not high.

Table 4. Estimate of investments

Sprinkling equipment	f 9 850
4 milk cows with their calves	- 5 000
Enlargement of cattle-house	- 1 500
1 fodder silo	- 500
1 haymaking machine	- 1 500
	f 18 350

Finally it should be remarked that the remunerativeness of irrigation cannot be predicted exactly, since the prices are subject to continual fluctuation.

However, for the existing price and cost level, we will be able to judge if irrigation of a farm will be remunerative and which working plan will be the most suitable. This is an important aid for the farmer as well for deciding to change over to sprinkler irrigation as for the further farm management.

Summary

For the farmer, who considers buying sprinkler equipment it is very important to know how much he will earn by sprinkling his farmland. Yet there are only few data available on this question. The difficulty is that the remunerativeness does not only depend on the water-holding capacity of the soil, but also to a large extent on the management of the farm. Sprinkling does pay only if the management is intensified. Fewer cereals will have to be grown and more root crops, pulses and eventually vegetables, and more cattle will have to be cultivated and kept. To what extent this is possible depends mainly on the labourers available. On every farm the degree of intensification will be different and so will the increase in income per acre. For every case, costs and returns of the non-irrigated farm have to be compared with the estimated costs and returns of the irrigated farm planned. Only in this way we can predict to what extent the changing over will presumably pay.

For such an estimate we need norms, not only the usual standards for labour, fertilization and feeding, but also standards for the yields of sprinkled crops, for the need for sprinkling and for the labour needed for moving the sprinkling tubes. In the Netherlands these specific irrigation standards are determined with the aid of 15 experimental farms for sprinkler irrigation.

Estimate of the increase in yield

We can calculate the value of the increase in yield by comparing the planned cropping scheme (with sprinkled crops) with the old one of the non-irrigated farm. For the value of the cash crops the average market price is taken. For the value of grass and other fodder plants, that of the gain in milk and the live-weight of the cattle is taken.

Estimate of the expenses for obtaining the increase in yield

The extra expenses are the following:

a. costs of the sprinkler equipment (depreciation, interest and cost of electricity or fuel);

b. costs of extra fertilizers for the new cropping scheme;
c. costs of extra seed for the new cropping scheme;
d. costs of extra concentrates and litter for the larger stock of cattle;
e. extra costs (depreciation, interest, cost of maintenance and insurance) for the larger buildings, the greater number of cattle and the extra machinery;
f. costs of extra man hours for moving the sprinkler equipment and for the new cropping scheme. For every month of the year the labour requirements of the to be sprinkled farm have to be compared with the labour available. If the new cropping scheme plus the moving of the sprinkler equipment will require more man hours, we must find out, how the gap will have to be filled and how much this will cost.

The remunerativeness of sprinkler irrigation is the difference between the value of the increase in yield and the expenses needed for obtaining this.

Such a calculation of the remunerativeness shows the farmer the profit of sprinkling and at the same time gives him a working plan. Besides that, he is informed on the extra labour requirements of the farm, when sprinkled, and on the investments needed.

ZUSAMMENFASSUNG

Die Berechnung der Rentabilität der Beregnung

Die Rentabilität der Beregnung ist eine für die Bauer sehr wichtige Frage. Dennoch sind darüber wenige Untersuchungen angestellt worden. Die Schwierigkeit ist, dass die Rentabilität nicht nur von der Wasserkapazität des Bodens, sondern auch in starkem Masse von den Betriebsverhältnissen abhängt. Die Beregnung macht sich nur bezahlt, wenn die Betriebsführung intensiver wird. Man muss weniger Getreide, aber mehr Hackfrüchte, Hülsenfrüchte und Gemüse anbauen und man muss das Grünland intensiver bewirtschaften. Wie weit sich diese Intensivierung durchführen lässt, hängt in der Hauptsache von den verfügbaren Arbeitskräften ab. In jedem Betrieb wird der Grad der Intensivierung wieder anders sein und damit auch der Wert des Mehrertrags je Hektar. Gleiches gilt für die Erzeugungskosten dieses Mehrertrags. Für jeden einzelnen Betrieb muss man die Erlöse und Kosten vor und nach der Einführung der beabsichtigten Beregnung einander gegenüberstellen, um die Rentabilität der Betriebsumstellung voraussagen zu können.

Für einen solchen Voranschlag braucht man Normen – nicht nur die allgemein gültigen Arbeits-, Düngungs- und Futternormen, sondern auch solche für die Erträge beregneter Kulturpflanzen, für die Bewässerungsbedürftigkeit der Pflanzen und für den Arbeitsbedarf der Beregnung. Diese besonderen Normen ermittelt man in den Niederlanden mit Hilfe 15 Beregnungsversuchsbetriebe.

Voranschlag des Mehrertrags

Den Wert des Mehrertrages können wir berechnen, wenn wir den alten Anbauplan mit unberegneten Beständen dem künftigen mit beregneten (mehr einbringenden) Beständen gegenüberstellen. Von den Verkaufsfrüchten nimmt man den durchschnittlichen Marktpreis als Wert auf. Als Wert des Grases und der anderen Futterpflanzen setzt man den der erzeugten Milch und den des Viehzuwachses ein.

Voranschlag der Erzeugungskosten des Mehrertrags

Dies sind folgende Kosten:
a. Betriebskosten der Regenanlage (Abschreibung, Zins und Energiekosten);
b. Mehrkosten für die Düngung infolge der Änderung des Anbauplanes;
c. Mehrkosten für Saat- und Pflanzgut infolge der Änderung des Anbauplanes;
d. Mehrkosten für Viehfutter infolge der Erweiterung des Rindviehbestandes;
e. Verschiedene Mehrkosten: Abschreibung, Zins, Versicherung, Unterhalt, usw. für die Erweiterung der Gebäude und des Viehbestandes und für zusätzliche Maschinen;
f. Mehrkosten für Arbeit infolge der Beregnung und der Intensivierung des Betriebs. Man muss den Arbeitsbedarf des künftigen beregneten Betriebs für jeden Monat des Jahres mit

der vorhandenen Arbeitskraft vergleichen. Ist nicht genügende Arbeitskraft vorhanden, so ist zu untersuchen, wie der Mehrbedarf gedeckt werden kann und wieviel das kostet.

Die Rentabilität der Beregnung ist der Unterschied zwischen dem Wert des Mehrertrags und dessen Erzeugungskosten.

Eine solche Rentabilitätsberechnung zeigt den Bauern den geldlichen Vorteil der Beregnung seines Betriebs und gibt ihm zugleich einen Arbeitsplan. Ausserdem erhält er Auskunft über den Mehrbedarf an Arbeitskraft des beregneten Betriebs und über die erforderlichen Investitionen.

DISCUSSION

MUNDBJERG:

The cost of sprinkling irrigation in Denmark.

The work was done by sending questionaires to 120 farmers who have irrigation systems. Irrigated area: 34 ha. Power: 32 hp. Power cost: 2.12 kr/h. Capacity: 45 m³/h. Cost of installations 32,500 Kr, per ha 950 Kr. Operating 600 hours for 80 mm/ha.

Men hours: 300 hours at 4 Kr.

Cost per ha: 10 years: 203 Kr.
15 years: 171 Kr.
20 years: 163 Kr.

incl. 225 Kr. per year for maintenance.

Antwort:

Die Investierungskosten sind in Holland etwas grösser, weil die Betriebe etwas kleiner sind. Die Betriebskosten sind dadurch auch etwas höher.

HALLGREN:

In my work during 15 years of planning irrigation systems one of the most difficult things has always been to estimate the labour costs. We have made some labour studies in Sweden, but the material concerning this problem is very small. It were therefore very valuable if the investigations in the Netherlands on the labour costs, mentioned by Mr. BAARS would be continued. Concerning Mr. MUNDBJERG's figures I will mention that it is not always true that a low installation cost will give the best economical results. We must also take into consideration the labour costs. These tend to increase with decreased installation costs.

MOLENAAR:

Total annual costs of irrigation in the Western United States vary from about $ 75 to $ 100 per ha. Labour costs are low in comparison to other costs, because of the relatively few irrigations per season, but the total is high in comparison to European costs because of the much higher total seasonal application of water.

SCHONNOPP:

Jahreskosten in Deutschland vergleichsweise etwa so hoch wie in Dänemark. Arbeitsaufwand der Beregnung kann durch das Verfahren der Schwachberegnung herabgedrückt werden. KTL-Veröffentlichung K.F. KLEIN „Handhabung und Arbeitswirtschaft der Beregnung im Bauernbetrieb".

Nicht ständige Bedienung, sondern Betrieb der Beregnung ohne Aufsicht automatisch. Vorschub der Leitungen und Regner zwischen den Betriebszeiten (bei Nacht) in den Betriebspausen (bei Tag).

Antwort:

Auf kleineren Betrieben ist Schwachberegnung vorzuziehen. Auf grösseren Betrieben mit einer Anlage von mehr als 100 m³/Stunde Fordermenge, werden in Holland noch mittelgrosse Regner benutzt, weil in diesem Fall der Arbeitsbedarf kleiner ist.