Discussion paper
No. 8

WHEAT PRODUCTION WITH SUPPLEMENTARY IRRIGATION IN TWO HAMA VILLAGES

by

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PREFACE

This paper was written by Elizabeth Bailey, a Research Assistant with ICARDA's Farming Systems Program. The information discussed is the result of regular monitoring of 33 farmers in two villages in Hama Province, conducted by Abdel Karim Ferdawi, also a Research Assistant with the Program, and the author. This is supplemented by information gained from informal discussions with these farmers during the three years of study.

This paper is seen as complementary to Section 4 of Internal Document Farming Systems Research Report No. 2 which gives a more general discussion of the farming systems of these two villages.

CONTENTS

SUMMARY

This paper examines whether the application of supplementary irrigation can eliminate the effect of variable annual rainfall and hence stabilize the yields, and production, of wheat. The information allows a comparison of a poor rainfall year (1978/79) with supplementary irrigation, with a good rainfall year (1979/80) when wheat was mainly rainfed.

Section 1 presents the proportional areas under rainfed and irrigated wheat in the two years studied. The proportional area under irrigated wheat varies each year according to the rainfall received.

The second section looks at inputs and yields of both rainfed and irrigated wheat, and the effect of irrigation on yields. In a dry year, the overall average output of irrigated wheat was more than double that of rainfed wheat, but in the good rainfall year rainfed yields alone were higher than the overall combined yield of the dry year. The application of supplementary irrigation, therefore, failed to overcome fluctuations in yield over the two years caused by variations in rainfall. However, within a single dry year, supplementary irrigation substantially modified the yield reductions caused by a low rainfall.

The third section shows how these fluctuating yields affect output, and the physical flow of wheat. A model is developed to show the effect of irrigation on output in a poor year compared to a good year. The analysis indicates that in one village (IRR/01), the combined yield of 1978/79 could not have produced the output achieved in 1979/80 even if the total area under wheat had been irrigated, or unless irrigated yields could be increased by 90 percent. In the other village (IRR/09), for the overall output of 1978/79 to compare with the rainfed output of 1979/80, a further 15 percent of the wheat area would need to be irrigated, or irrigated yields would have to be increased by 33 percent. In addition it was shown that response, in terms of output, to a percent increase in the irrigated area of wheat was higher in a dry year than a good year.

The fourth section, by combining physical and financial flows, shows how the variation in production affects the farmers' returns from wheat. The model developed in section 3 is used to examine the changes in net output over the two years and the effect of price changes. In 1979/80, a year of high wheat production, prices of wheat were lower. If data is adjusted for this, net outputs in the good rainfall year, 1979/80,are increased further.

Appendices contain detailed data on wheat production in the two villages studied over the two years.

INTRODUCTION

One of the main uncertainties faced by farmers in dry regions stems from yield fluctuations associated with variability in annual rainfall. (Fitch and Nordblom, 1977; Oregon State University, 1979). A large proportion of variation over years in production and therefore farm income can be attributed to yield fluctuations.

The purpose of this paper is to examine whether the availability of supplementary irrigation can reduce the effects of variable annual rainfall on wheat yields, and hence, stabilize production. If similar yields of wheat can be obtained in poor years, with supplementary irrigation, to those obtained in good rainfall years, then irrigation becomes a risk-reducing strategy for poor rainfall years, securing a constant return of wheat each year. Not only would this benefit the farmers concerned, but as they tend to be surplus producers of wheat, any stabilization of production would have a direct effect on the national food supply.

The role of irrigation in wheat production at a national level has already been examined by the Economic Commission for Western Asia (ECWA 1978), but the data presented here allows us to examine what is happening at the farm level.

A full description and analysis of the farming systems of the two villages from data collected in the first year (1978/79) is presented in Section 4 of Research Report No. 2 (Farming Systems Program 1980a). However, an additional season's data makes possible a comparison of a poor rainfall year (1978/79) in which a relatively large proportion of the wheat received supplementary irrigation, with a good rainfall year (1979/80) when wheat was mainly rainfed. It is intended that this paper will contribute to the Farming Systems Program's research into the effects of irrigation on rainfed production systems.

In addition, this paper demonstrates how, by employing similar techniques to those used in the analysis of the whole farming system in Sections 3 and 4 of Research Report No. 2 (Farming Systems Program 1980a), the Village Level Studies data can be utilized to examine one particular cropping enterprise in detail. While this should be of particular interest to ICARDA's Cereal Improvement Program, data and conclusions drawn from this study should also be considered in the light of the system as a whole.

1. THE POSITION OF WHEAT IN THE CROPPING SYSTEMS

Wheat is of great importance in these villages, both in terms of its income generation to the farmers concerned, and its contribution to the food supply of urban populations.

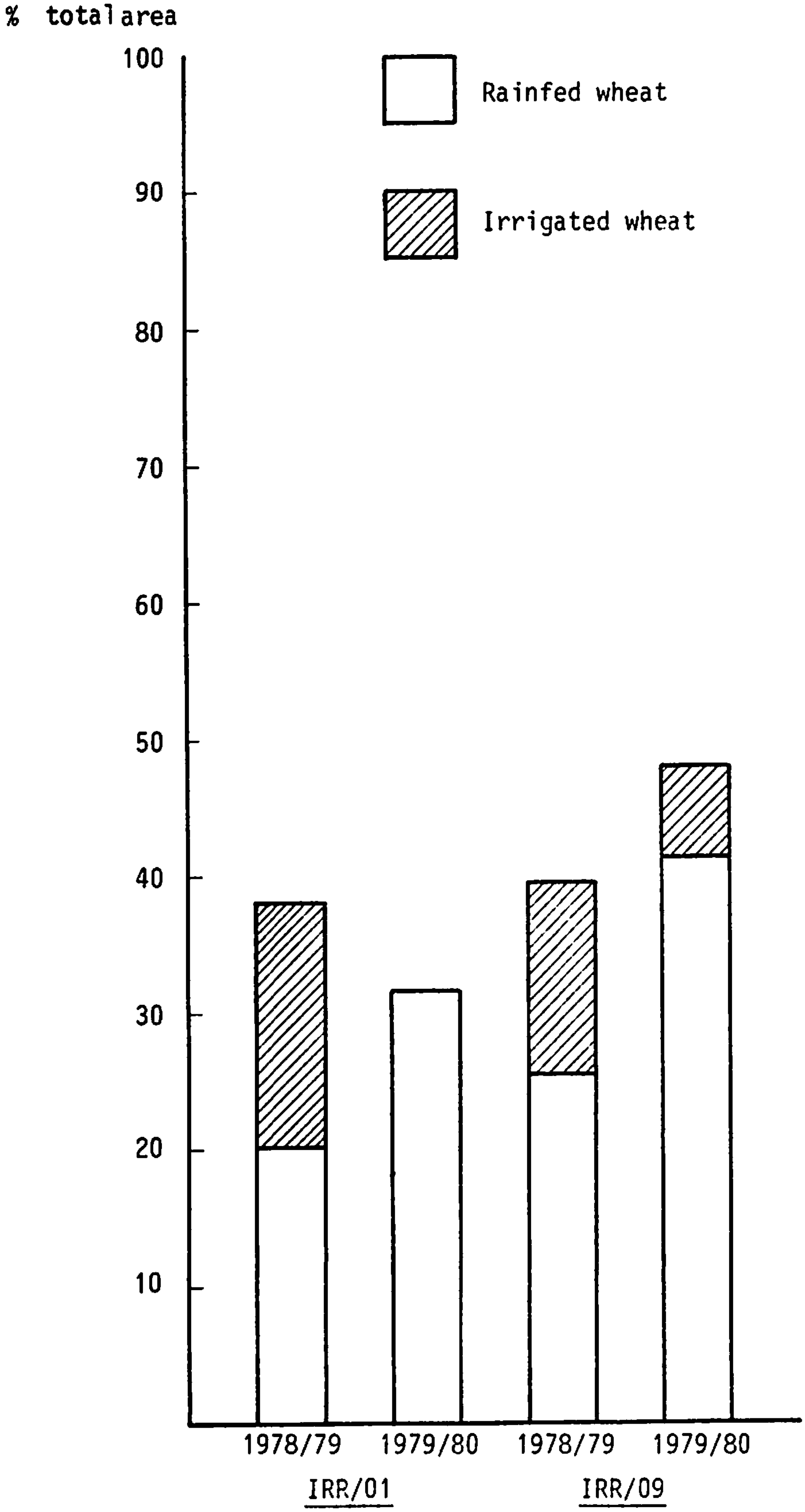
Wheat is the major crop in both villages in terms of allocation of land. Table 1 presents the proportional areas under rainfed and irrigated wheat in relation to the total cultivated area, and the total area under wheat for the two villages, and is reproduced graphically in Figure 1.

TABLE 1 PROPORTIONAL AREAS UNDER RAINFED AND IRRIGATED WHEAT, IRR/01 and IRR/09, 1978/79 and 1979/80

	IRR/01		IRR/09	
	1978/79	1979/80	1978/79	1979/80
As % total cultivated area:				
Rainfed wheat	20.1	31.4	25.4	41.2
Irrigated wheat	17.8	0	14.2	6.7
Total wheat	37.9	31.4	39.6	47.9
As % total wheat area:				
Rainfed wheat	53.0	100.0	64.1	86.0
Irrigated wheat	47.0	0	35.9	14.0

Changes in the total area planted to wheat over the two years are mostly due to rotational factors.

FIGURE 1 PERCENT AREA ALLOCATION TO WHEAT



Changes in the proportional area of irrigated wheat over the two years are due to several factors:

1. All wheat in the two villages is planted as a rainfed crop. Farmers irrigate that wheat planted on irrigable land if they consider the rainfall to be inadequate, but water is not applied until March or early April. The proportional area of irrigated wheat therefore reflects the rainfall received in that year.

2. Another factor accounting for the reduced irrigated area in 1979/80 is the source of irrigation water. The first village, IRR/01, is served by a state canal system and the decision as to whether the year has been dry enough to justify opening the canal before April to allow spring irrigation of wheat, is taken by the Ministry. The canal remained closed in 1979/80 until April and Therefore no wheat was irrigated. In the other village, IRR/09, irrigation is from private boreholes and a few plots were irrigated in 1979/80.

On rainfed land, wheat rotates with other winter crops, barley, lentil and vetch, and rainfed summer crops - water melon and melon. On irrigable land, it rotates with irrigated summer crops: potatoes, cotton, onions, etc.

Both villages are surplus producers of wheat, and it is becoming an important cash crop alongside cotton, potatoes and onions.

It is against this background that we will examine the role of supplementary irrigation in the production of wheat.

2. YIELDS

As a crop that is grown in Syria both under rainfed conditions and with supplementary irrigation, wheat can be used as a direct measure of the effect of irrigation in terms of yield. A comparison of rainfed and irrigated wheat yields within one year in each village will show the direct effect of supplementary irrigation, whereas an examination of yields over the two years will give an idea of whether irrigation reduces the fluctuations in yields normally caused by the variation in annual rainfall.

Total rainfall was similar for the two villages in 1978/79, but there was a marked difference in both total rainfall and distribution in 1979/80. Therefore, the data from the two villages is treated separately. Rainfall figures for the two villages are given in Appendix I.

Mean inputs and yields for both rainfed and irrigated wheat are presented in Table 2 for IRR/01 and Table 3 for IRR/09, and mean yields are presented graphically in Figure 2.[1/]

About 47 percent of the wheat area in IRR/01, and 36 percent in IRR/09, was irrigated in 1978/79, and the effects of irrigation can be clearly seen. Yields of irrigated wheat were 108 percent higher in IRR/01 and 173 percent higher in IRR/09, than those of rainfed wheat. These increases in yield can be attributed mainly to irrigation. Differences in inputs between rainfed and irrigated wheat were slight in IRR/01. In IRR/09, more fertilizer, particularly nitrogen, was applied to irrigated wheat, but this is a reflection of the farmers' view that the previous crops -- irrigated cotton and potatoes -- deplete the soil of nutrients and therefore, a following crop of wheat, whether rainfed or irrigated, requires more fertilizer.

1/ Yields presented in this paper are yields reported by farmers, frequently converted from a quantity in sacks. However, these reported yields are confirmed by the Farming Systems Program's farmers field crop sampling results.

If we compare data from the two years, it can be seen that the combined wheat yields in 1979/80 were much higher than those of 1978/79. No wheat was irrigated in IRR/01 in 1979/80 and therefore this increase is due to an increase in rainfed wheat yields alone. Not only did the 1979/80 rainfed wheat yield exceed the combined wheat yield of 1978/79 by 47 percent, but it also exceeded the irrigated wheat yield of 1978/79. Thus, in a poor rainfall year, supplementary irrigation in this village did not produce the yields achieved by rainfed wheat in a good rainfall year.

In IRR/09, only 14 percent of the wheat area was irrigated in 1979/80, compared with 36 percent in the previous year, but the combined yield was still higher. However, while the mean yield of irrigated wheat was higher in 1979/80, the proportional increase of 67 percent over that of rainfed wheat was well below that of the 173 percent increase seen in 1978/79.

This is only a preliminary examination and it is difficult to assess how much of the yield increase in 1979/80 can be attributed to the higher rainfall alone.[1/] Higher rates of nitrogen fertilizer were applied in both villages in 1979/80. In IRR/01 this was due to the cooperatives' failure in 1978/79 to acquire nitrogen fertilizer in time for application at planting.

A greater proportion of the wheat area was planted to higher yielding varieties in 1979/80, than in 1978/79. Varieties grown by sample farmers in 1978/79 were:

In IRR/01: Local (Bayadi); Mexipak; Senator Capelli; Jori; Georgette.

In IRR/09: Bayadi; Mexipak; Florence Aurore; Senator Capelli; and one plot of Georgette.

1/ Distribution and intensity of rainfall would also have to be taken into account, but these factors are outside the scope of this paper.

TABLE 2 MEAN INPUTS AND YIELDS FOR RAINFED AND IRRIGATED WHEAT OVER TWO YEARS: 1978/79 and 1979/80 VILLAGE IRR/01

	1978/79			1979/80
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Total Wheat 2/
No. of observations	29	35	64	58
Date of planting	8.12.78	13.12.78	--	28.11.79
Seed rate (kg/ha)	201.6 (44.2)1/	228.0 (51.2)	215.8 (49.5)	239 (53.5)
P_2O_5 (kg/ha)	112.9 (43.5)	89.5 (21.9)	97.3 (30.2)	68.75 (23.6)
N (Winter) (kg/ha)	--	--	--	32.4 (21.7)
N (Spring) (kg/ha)	51.4 (15.7)	60.3 (27.5)	56.1 (23.0)	57.7 (14.8)
N (Total) (kg/ha)	51.4 (15.7)	60.3 (27.5)	56.1 (23.0)	58.8 (14.5)
% of plots receiving herbicide	n.a.	n.a.	n.a.	39.7%
Date of harvest	14.6.79	15.6.79	--	5.7.80
Grain yield (kg/ha)	1167 (326.8)	2425 (989.4)	1855 (986.8)	2729 (1045.0)
Straw yield (kg/ha)	2310 (1147.4)	3816 (1414.4)	3394 (1490.6)	3059 (1682.4)
Total yield (kg/ha)	3614 (1255.3)	6151 (2246.9)	5441 (2307.0)	6157 (2667.1)

1/ Standard deviations are given in parentheses.

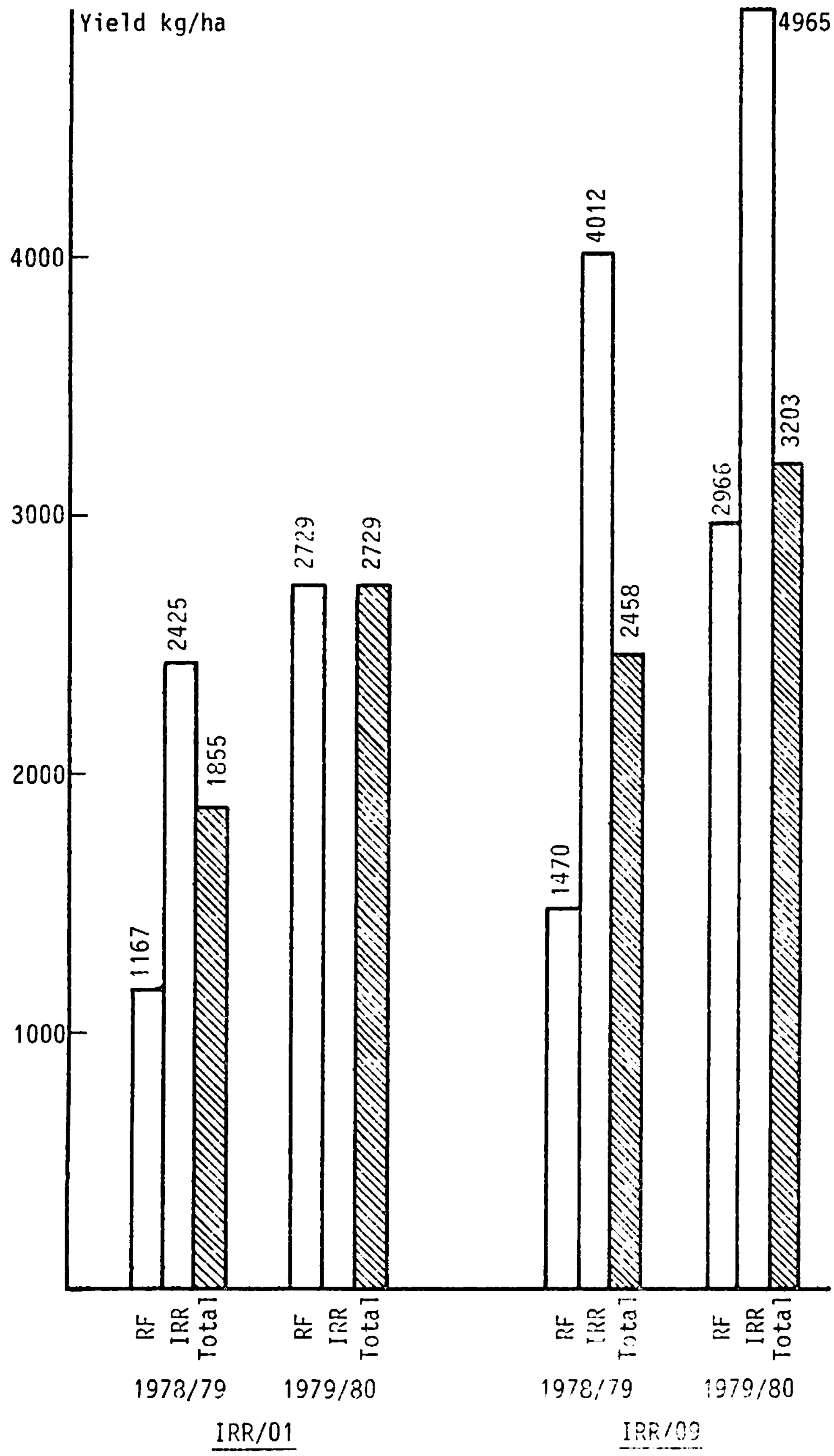
2/ All wheat in IRR/01 was rainfed in 1979/80.

TABLE 3 MEAN INPUTS AND YIELDS FOR RAINFED AND IRRIGATED WHEAT OVER TWO YEARS: 1978/79 and 1979/80 VILLAGE IRR/09

	1978/79			1979/80		
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Rainfed Wheat	Irrigated Wheat	Total Wheat
No. of observations	22	14	36	52	7	59
Date of planting	11.12.78	7.12.78	--	4.12.79	3.12.79	--
Seed rate (kg/ha)	197.1 (31.5)1/	227.4 (59.5)	208.6 (45.9)	232.3 (35.4)	223.7 (54.4)	231.2 (37.6)
P_2O_5 (kg/ha)	93.1 (27.8)	114.5 (35.9)	101.2 (32.4)	96.7 (36.3)	83.0 (39.8)	95.1 (36.6)
N (Winter) (kg/ha)	32.4 (13.0)	36.0 (11.0)	33.9 (12.2)	56.6 (27.7)	53.6 (23.2)	56.2 (27.0)
N (Spring) (kg/ha)	47.4 (16.9)	90.0 (33.8)	75.2 (35.2)	95.6 (54.4)	88.1 (30.5)	94.4 (51.2)
N (Total) (kg/ha)	44.3 (26.9)	111.9 (42.9)	72.1 (47.8)	121.0 (72.2)	141.7 (34.8)	123.5 (68.9)
% plots receiving herbicide	n.a.	n.a.	n.a.	77.0	100.0	80.0
Date of harvest	26.5.79	3.6.79	--	17.6.80	24.6.80	--
Grain yield (kg/ha)	1470 (417.3)	4012 (1111.4)	2458 (1463.7)	2966 (1241.8)	4965 (1672.1)	3203 (1438.8)
Straw yield (kg/ha)	--	--	--	--	--	--
Total yield (kg/ha)	--	--	--	--	--	--

1/ Standard deviations are given in parantheses.

FIGURE 2 MEAN RAINFED & IRRIGATED WHEAT YIELDS IRR/01 & IRR/09



In 1979/80 the number of varieties had increased and included larger areas planted to Georgette, Jori and Jezireh 17, the seed being obtained from the government seed office. These varieties are seen as being higer yielding and are grown primarily for sale.[1/] As larger areas were planted to these varieties in 1979/80, this could also partly account for the increase in yields.

Mean yields by variety and soil type are presented in Appendices II and III.

In this section it has been shown that in one year (1978/79) irrigation more than doubled yields. Over the two years studied, the application of supplementary irrigation did not overcome the fluctuations in yield over time caused by the variation in annual rainfall, but did go some way towards reducing those fluctuations. In both villages rainfed yields, and consequently total output, in a good rainfall year were higher than combined rainfed and irrigated yields in a poor year.

1/ The increasing adoption of new varieties, and farmers' wheat type preference, is discussed in Section 4 of Research Report No. 2 (ICARDA, 1980a).

3. PRODUCTION AND PHYSICAL FLOWS OF WHEAT

This section aims to demonstrate the effects on overall output of the variable yields discussed in Section 2.

Table 4 presents production by the farmer sample over the last four years in the two villages. The data for the first two years are taken from information collected on the cropping history of farmers' plots and, being based on farmers's recall, may contain some error. It can be seen that not only does total output fluctuate considerably over the years, but so do yields, i.e., output per hectare.[1/]

A detailed examination of the two years' data will demonstrate whether the use of supplementary irrigation in a poor rainfall year can compensate for lower rainfed yields and make overall wheat production up to a level achieved through higher rainfed yields in a good rainfall year.

3.1 Production Over Two Years: 1978/79 and 1979/80

Since output is determined by the area under the crop and the yield per unit area, its variability is the result of the variation in area and/or yield.[2/] When a crop is grown under both rainfed and irrigated conditions the total output is determined by the rainfed area times the rainfed yield plus the irrigated area times the irrigated yield. Using the proportional areas under rainfed and irrigated wheat, overall average output can be expressed as '

1/ These differ from the yields discussed in Section 1 which are the mean plot yields which allow comparison between rainfed and irrigated plots to be made, and which can be related to plot input rates per hectare.

2/ This is discussed at the national level by ECWA (1978).

TABLE 4 SUMMARY OF OUTPUT OVER FOUR YEARS: 1976/1980

IRR/01 AND IRR/09

	IRR/01			IRR/09		
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Rainfed Wheat	Irrigated Wheat	Total Wheat
1976/1977						
Area (ha)	40.2	5.85	46.05	68.8	7.2	76.0
Output (kg)	73473	16251	89724	108814	20250	129064
Yield (kg/ha)	1828	2778	1948	1582	2813	1698
% irrigated area	--	--	12.7%	--	--	9.5%
1977/1978						
Area (ha)	23.25	9.5	32.75	85.5	0.2	85.7
Output (kg)	41188	20939	62127	169790	250	170040
Yield (kg/ha)	1772	2204	1897	1986	1250	1984
% irrigated area	--	--	29.0%	--	--	0.23%
1978/1979						
Area (ha)	22.9	20.3	43.2	45.8	25.6	71.4
Output (kg)	27464	48415	75877	72112	107558	179670
Yield (kg/ha)	1199	2385	1756	1574	4201	2516
% irrigated area	--	--	47.0%	--	--	35.9%
1979/1980						
Area (ha)	35.7	--	35.7	74.2	12.0	86.2
Output (kg)	98677	--	98677	216652	64134	280786
Yield (kg/ha)	2764	--	2764	2920	5345	3257
% irrigated area	--	--	0%	--	--	13.9%

$$Y = aR + bI \qquad \text{(Equation I)}$$

where: Y = average output (kg/ha),
a = the proportion of the total wheat area under rainfed wheat,
b = the proportion of the total wheat area under irrigated wheat,
R = rainfed wheat yield (kg/ha), and
I = irrigated wheat yield (kg/ha).

This is presented graphically in Figure 3 for the two years in IRR/09, and one year in IRR/01: no wheat was irrigated in 1979/80 in IRR/01 and therefore, Y = R, when a = 1 (100 percent rainfed).

Figure 3 shows how much greater an area would have had to have been irrigated, or what increase in irrigated yields would have been necessary, in 1978/79 to achieve the rainfed output obtained in 1979/80. This can be achieved by solving for b or I in Equation (I).

Since by definition a+b=1, Equation (I) can be expressed as

$$Y = (1-b)R + bI. \qquad \text{(II)}$$

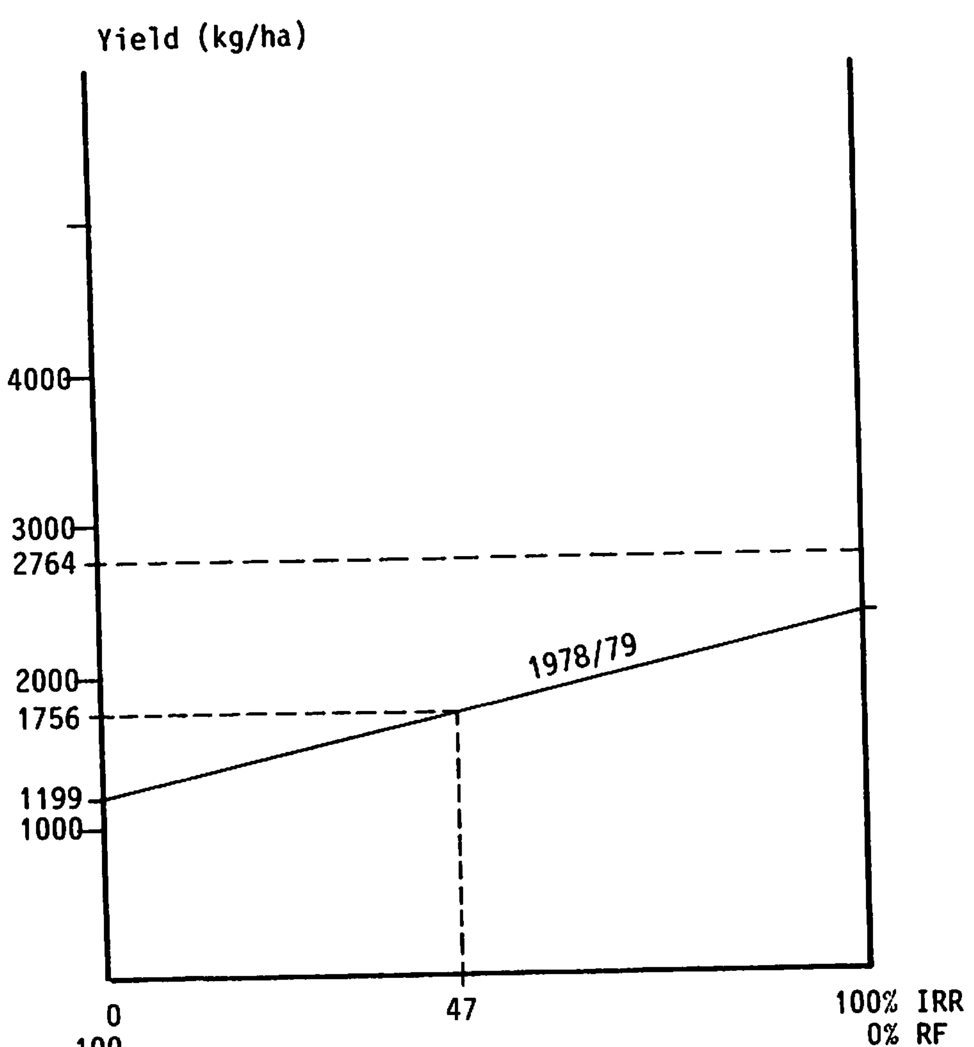
Solving for b, it therefore follows that

$$b = \frac{(Y-R)}{(I-R)} \qquad \text{(III)}$$

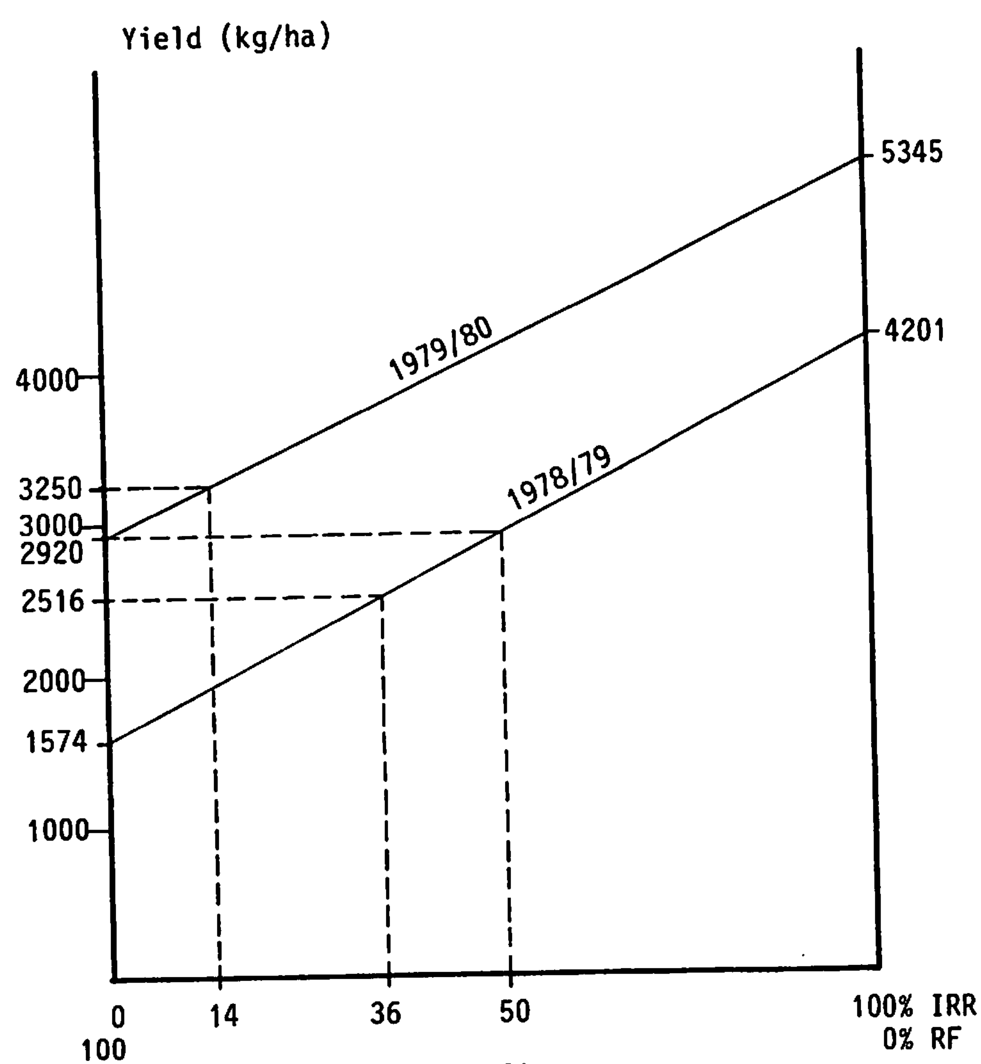
and solving for I

$$I = \frac{Y-aR}{b}. \qquad \text{(IV)}$$

FIGURE 3 TOTAL YIELDS (kg/ha) OF WHEAT ACCORDING TO PROPORTIONAL AREAS UNDER RAINFED AND IRRIGATED WHEAT



IRR/01



IRR/09

In IRR/01, the combined yield in 1978/79 was less than that of rainfed wheat alone in 1979/80. Therefore, with the rainfed and irrigated yields of 1978/79, IRR/01 could not have reached the 1979/80 output level even if the total area under wheat had been irrigated. This is clearly shown in Figure 3. If we take the rainfed yields as fixed, then to reach a similar output to that in 1979/80 on the proportional areas of 1978/79, irrigated yields would have had to increase by 2144 kg/ha to 4529 kg/ha, an increase of 90 percent:

$$I = \frac{2764 - (0.53 \times 1199)}{0.47}$$

In IRR/09, for the overall output per hectare in 1978/79 to reach the rainfed output level of 2920 kg/ha in 1979/80,

$$b = \frac{2920 - 1574}{4201 - 1574}$$

about 51 percent of the total area would have needed to have been irrigated, i.e., a further 11 hectares of the sample farmers' total area under wheat. Alternatively, if proportional areas under rainfed and irrigated wheat remain fixed, then the irrigated yields in 1978/79 would have had to increase to 5323 kg/ha to achieve a similar output to 1979/80:

$$I = \frac{2920 - (0.641 \times 1574)}{0.359}$$

Of further interest is the slight difference between the slopes of the lines for the two years in IRR/09. This indicates that there is a difference in the response, in terms of yield, to irrigation over the two years. By using Equation (I) we can see the returns in output to an increase of one percent in the area irrigated in the two years:

If $$Y = aR + bI$$

and $$Y_1 = (a-0.1)R + (b+0.1)I$$

then $Y_1 - Y$ = The increase in output due to one percent increase in the irrigated area.

For 1978/79:

$$Y = 0.6415\ (1574) + 0.3585\ (4201)$$
$$Y_1 = 0.6315\ (1574) + 0.3685\ (4201)$$

and $Y_1 - Y \doteq 26.27$ kg/ha

For 1979/80:

$$Y = 0.8608\ (2920) + 0.1392\ (5345)$$
$$Y_1 = 0.8508\ (2920) + 0.1492\ (5345)$$

and $Y_1 - Y = 24.25$ kg/ha, and therefore the response was higher in 1978/79, than in the good rainfall year of 1979/80.

However, if the farmers had irrigated the same proportional area in 1979/80, as in 1978/79, the combined rainfed and irrigated yield would have been 3789 kg/ha, an increase of 539 kg/ha over the actual combined yield.

3.2 Physical Flows Over Two Years

By looking at the complete physical flow of a commodity we can get an idea of input-output relationships and whether the system is surplus generating or deficient. From the flows we can calculate net flows (Δ Flow), i.e., transfers out of the system less transfers into the system, and this combined with the change in stocks (Δ Stocks) gives the system change (Δ System).

Wheat flows for 1978/79 are presented elsewhere (ICARDA 1980a). Those calculated for 1979/80 are only "partial" flows as they do not take account of wheat purchased for and consumed by livestock and the household. Therefore, for comparative purposes, 1978/79 wheat flows have also been reduced to "partial" flows. This should have little effect as large quantities of wheat were not purchased for the household or livestock, and it can be assumed that quantities transferred into these sectors from the production sector are consumed within the twelve-month period.

Appendix IV presents wheat flows, in kilograms, gross and per hectare for the farmer sample in the two villages over two years. The Δ System is high in both villages indicating that not only are they self sufficient in wheat, but are also generating large surpluses. In 1979/80, IRR/01 harvested a further 1008 kg/ha, and IRR/09 739 kg/ha, above that harvested the previous year.

It can be seen how this greater production was utilized:

1. As output increases, the amount delivered as rent and paid to combine harvester operators also increases, as these are charged as a proportion of the yield.[1/]

2. In IRR/01, the amount transfered to the household increased in 1979/80: 280 kg/person compared to 175 kg/person in 1978/79, while in IRR/09 it decreased from 179 kg/person in 1978/79 to 156 kg/person in 1979/80.

3. Transfers to livestock (normally in the form of bad or dirty wheat) remained fairly constant.

1/ Combine harvester operators are paid in cash in IRR/01

4. Less wheat was kept in stock for seed (as indicated by Δ Stock) due to more farmers using new varieties and preferring to purchase new seed each year.

5. The remainder of the production was released for sale, and this amount has increased considerably over the two years.

Table 5 shows the amounts sold (contributing to the urban food supply) by the sample farmers, and by the village as a whole.

TABLE 5 WHEAT SALES (TONS) BY FARMER SAMPLES AND BY THE VILLAGE,[1/] OVER TWO YEARS

Year	IRR/01		IRR/09	
	Farmer Sample	Village	Farmer Sample	Village
1978/79	31	129	102	317
1979/80	43	179	172	537

Table 6 presents some indices that give an indication of the productivity of the systems. Both villages generated a larger Δ System per person in 1979/80. In the case of IRR/01, the larger Δ system compensates for the smaller area planted to wheat in IRR/01 in 1979/80. The Δ system/yield (%) shows the relative surplus generation of the village system which is much higher in IRR/09.

1/ Village sales calculated by:

$$\frac{\text{Sales of farmer sample}}{\text{No. of farmers in sample}} \times \text{No. of farmers in village}$$

TABLE 6 INDICES OF PRODUCTIVITY OVER TWO YEARS IRR/01 AND IRR/09

	IRR/01		IRR/09	
	1978/79	1979/80	1978/79	1979/80
Δ System/ha of wheat (kg)	847	1317	1887	2729
Δ System/person (kg)	273	351	817	1426
Hectare wheat/person	0.32	0.27	0.43	0.52
Average yield (kg/ha)	1855	2729	2458	3203
Δ System/yield (%)	45.7	48.3	76.8	85.2

3.3 The Effect of Irrigation

By adjusting the data these wheat flows can be used to measure the effect of irrigation. This can be achieved as follows: if the average yields and seed rates for rainfed wheat are applied to the total area under wheat and figures in the system are thus adjusted, the wheat flow then represents the system as it would be under rainfed conditions only. Transfers outside the system -- to combine harvester, rent, and gifts -- are calculated on the same ratio to quantity harvested in the actual wheat flow. Transfers to household and livestock remain the same as in the original flow, and sales are calculated as the residual.[1/] Figures for Δ Stocks remain the same, but Δ Flows and Δ System are greatly reduced in 1978/79 as shown in Figure 4. The flow remains unaltered for 1979/80 in IRR/01 as no wheat was irrigated. The adjusted flows are presented in Appendix VI.

1/ An example of adjusted flows for an individual farmer in village IRR/09 is given in Appendix V.

Major indices of production from these "adjusted" flows are given in Table 7, and should be compared with those in Table 6.

TABLE 7 INDICES OF PRODUCTIVITY FROM "ADJUSTED" WHEAT FLOWS

	IRR/01		IRR/09	
	1978/79	1979/80[1/]	1978/79	1979/80
Δ System/ha of wheat (kg)	268	1317	852	2435
Δ System/person (kg)	86	351	369	1272
average yield (kg/ha)	1167	2729	1470	2966
Δ System/yield (%)	23.0	48.3	58.0	82.1

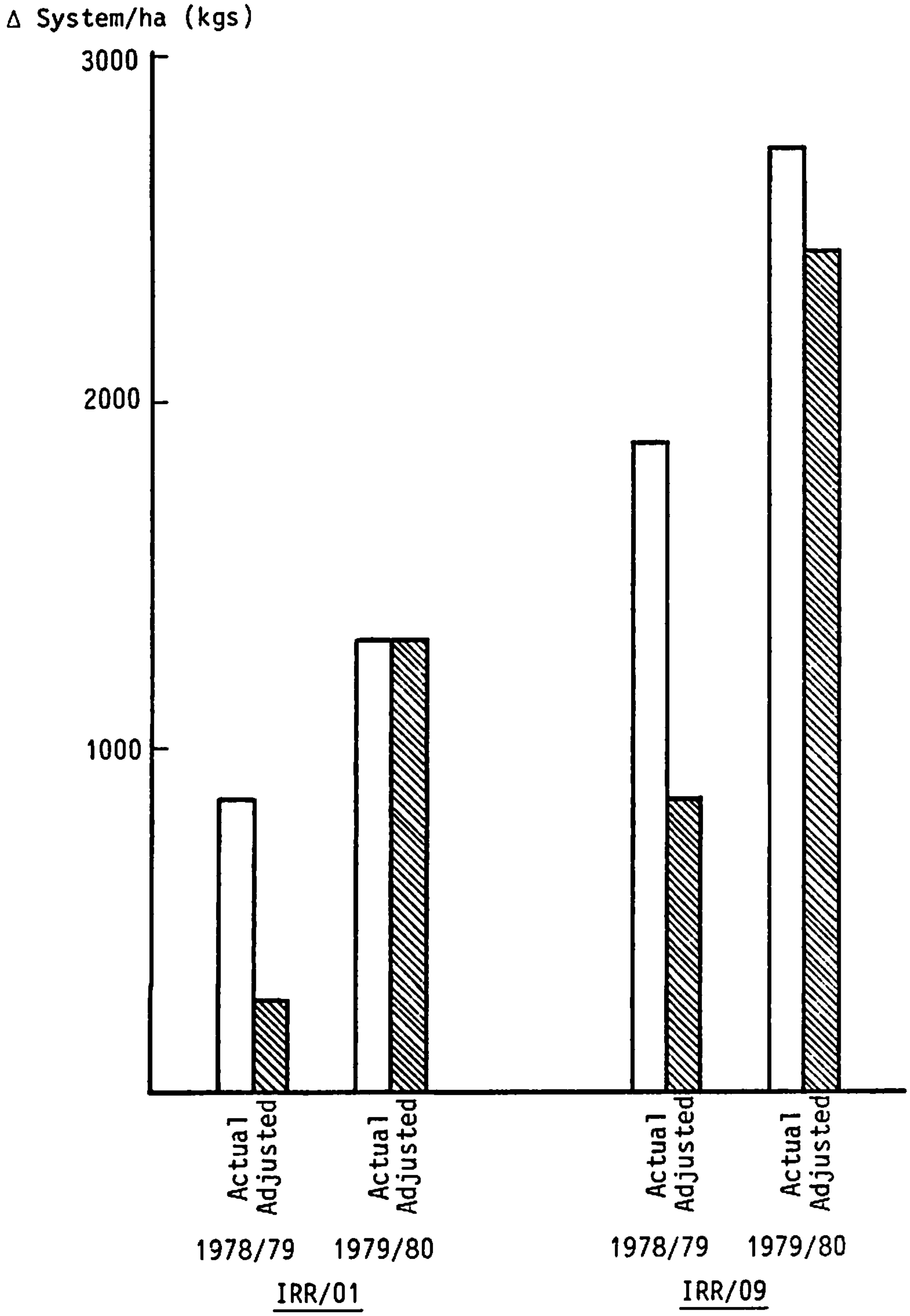
These adjusted data can be used in several ways.

1. Firstly, we can see the effect of irrigation within one year. By comparing the adjusted and actual wheat flows in 1978/79, it can be seen in Figure 4 that the use of supplementary irrigation had considerable impact. On a per hectare basis, irrigation increased the Δ System by 240 percent in IRR/01, and 128 percent in IRR/09. Also, in IRR/01, with a Δ System of 86 kilograms per person the village would have been barely self sufficient had no wheat been irrigated.

2. Secondly, by comparing the adjusted wheat flows of the two years, the effect of irrigation is eliminated and we can see the effect of the variability in annual rainfall alone. The Δ System per hectare in 1979/80 increased by 390 percent in IRR/01, and 186 percent in IRR/09 compared with 1978/79. This again can be seen clearly in Figure 4.

1/ These remain the same as the original wheat flows as all wheat was rainfed.

FIGURE 4 Δ SYSTEM/HA FROM ACTUAL AND ADJUSTED FLOWS



3. Thirdly, by comparing the adjusted wheat flows of 1979/80, thereby converting both villages into rainfed systems, with the actual wheat flows, for 1978/79, we can see whether the use of supplementary irrigation in the first year increased the production to a level similar to that achieved in a good rainfed year such as 1979/80. The figures in Table 8 show that supplementary irrigation did not fully compensate for the poor rainfall conditions in 1978/79.

TABLE 8 INDICES OF PRODUCTION FROM ACTUAL FLOWS IN 1978/79, COMPARED WITH ADJUSTED FLOWS 1979/80

	IRR/01		IRR/09	
	1978/79 Actual Flow	1979/80 Adjusted Flow	1978/79 Actual Flow	1979/80 Adjusted Flow
Yield (kg/ha)	1855	2829	2458	2966
Δ System/ha	847	1317	1887	2435
Δ System/yield (%)	45.7	48.3	76.8	82.1

4. NET OUTPUTS

There are several measures of productivity, yield as discussed in Section 2, being the simplest. A better measure was given by the physical productivity of the system (Δ System). However, true productivity can only be measured by taking into account all inputs and all outputs. To evaluate the system fully, it is necessary to put a moneraty value on all physical flows and to combine these with financial flows, i.e., cash expenditure and income. Net output is then the balance of all output less all costs and is thus a compound measure of technical productivity (ICARDA 1980b).

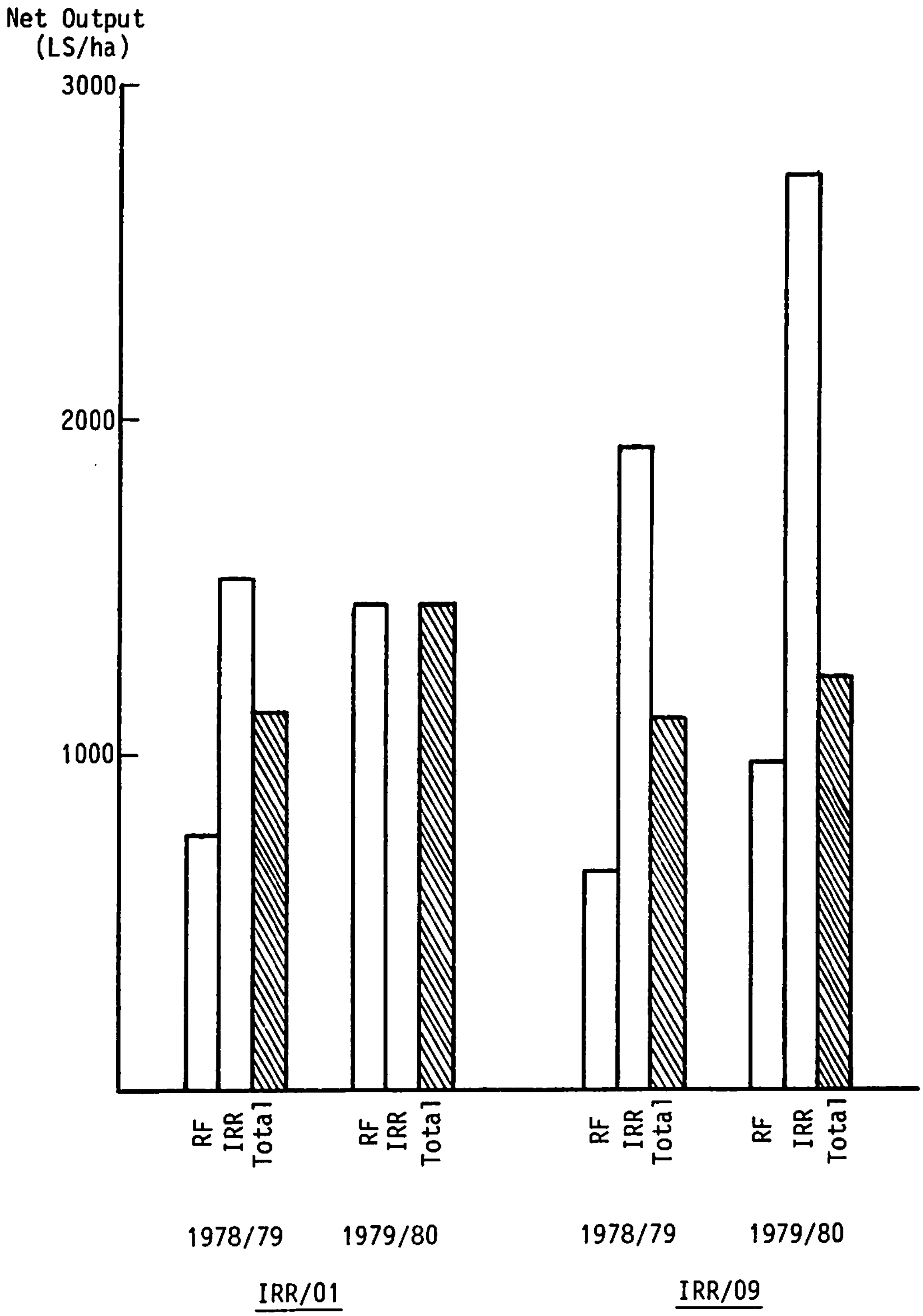
Figure 5 compares net output per hectare for the two villages over two years. The effect of irrigation can be clearly seen. Appendix VII and VIII show the composition of net output for rainfed, irrigated and total wheat over two years, for IRR/01 and IRR/09 respectively.

In 1978/79 irrigation increased the net output by 761 SL/ha (98 percent) in IRR/01, and 1262 SL/ha (191 percent) in IRR/09, despite the higher costs involved in irrigation from private boreholes. This reflects the higher increase in yields discussed in Section 1.

When looking at both years, rainfed net outputs in IRR/01 in 1979/80, and therefore, combined net output since no wheat was irrigated, was higher than the combined net output of the previous year, an increase of 329 SL/ha (29 percent). However, in IRR/09, the situation was different.

In IRR/09, if all the wheat in 1979/80 had been rainfed, the combined net output per hectare would have been lower than that of 1978/79. Even with 14 percent of the wheat area irrigated in 1979/80, the combined net output was only 108 SL/ha (10 percent) higher than that of the previous year.

FIGURE 5 NET OUTPUTS FROM RAINFED, IRRIGATED, AND TOTAL WHEAT OVER TWO YEARS



Using the model developed in Section 3.1, and by substituting combined or total net output per hectare for total output per hectare:

$$NO = aR + bI \qquad \text{(Equation V)}$$

where: NO = total net output
a = proportion of total wheat area under rainfed wheat
b = proportion of total wheat area under irrigated wheat
R = rainfed wheat net output (SL/ha)
I = irrigated wheat net output (SL/ha)

This is presented graphically in Figure 6. Again, we can see how large an area would have had to have been irrigated in 1978/79, to achieve the net output of 1979/80.

In IRR/01, the farmer sample would have needed to irrigate 90 percent of their wheat land (a further 18.6 hectares) to achieve a total net output equal to that for rainfed wheat alone in 1979/80, since,

$$b = \frac{1461 - 774}{1535 - 774}$$

In IRR/09, the net output for rainfed wheat in 1979/80 is less than the total net output for rainfed plus irrigated wheat in 1978/79 and therefore the comparison does not apply.

In IRR/01, the higher net output gained in 1979/80 under rainfed conditions demonstrates that the use of irrigation in 1978/79 did not fully compensate for the deficit in rainfall.

In IRR/09, despite the fact that rainfed yields were higher in 1979/80 than the combined rainfed and irrigated yield for 1978/79 (see Figure 3), net outputs were reduced. This reflects the higher investment, in terms of inputs, in wheat in IRR/09.

FIGURE 6 NET OUTPUT OF WHEAT ACCORDING TO PROPORTIONAL AREAS UNDER RAINFED AND IRRIGATED WHEAT

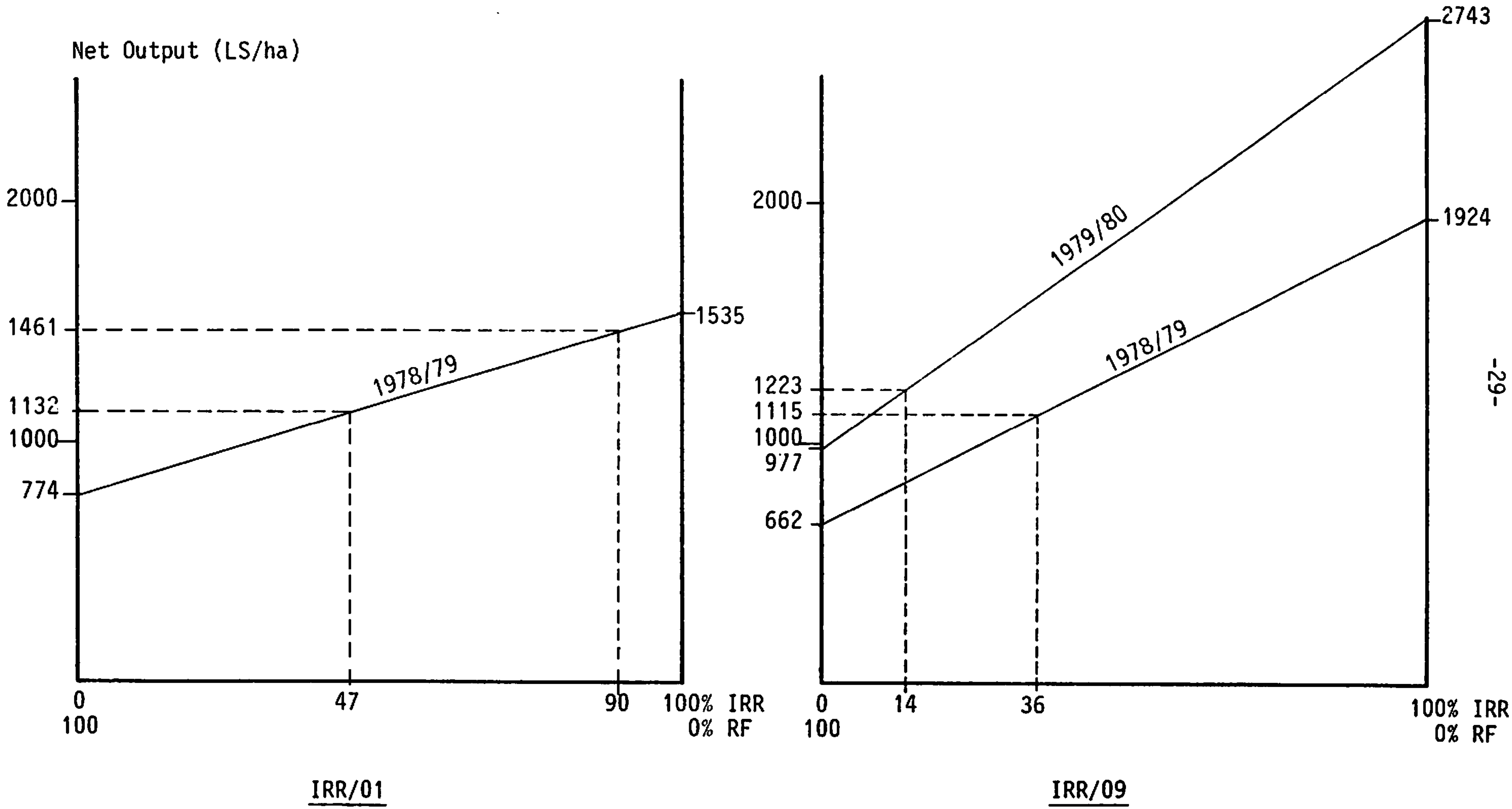


Table 9 presents rate of return as an index of profitability. Although total output was higher in IRR/09 than in IRR/01, net outputs were almost identical in 1978/79 and lower in 1979/80. This is reflected in the lower rates of return for IRR/09. Farmers in IRR/09 are generating a higher productivity per hectare (see page 21) but a lower productivity per unit of investment.

Appendix IX presents the components of net output as proportions and it is possible to see which components contributed the most to net outputs. By far the largest contributor in IRR/09 was the cash income/expenditure balance. The variation in expenditure over the two years may be partly attributed to price changes, and to get a truer comparable measure of productivity the output side of the net output calculation should also be adjusted for price changes. The valuation (based on government prices) used for wheat in 1978/79 was 1.10 SL/kg for both bread and durum wheat. In 1979/80, a year of high production, the price dropped to 0.85 SL/kg for durum, and 0.75 SL/kg for bread wheats.

Equation V can be used to examine the effect of price changes and this is demonstrated in Figure 7. Appendix IX presents 1979/80 net outputs (SL/ha) for rainfed, irrigated and total wheat, adjusted to the 1978/79 price of 1.10 SL/kg.

The adjustment in prices in IRR/01 raises the net output by 396 SL/ha in 1979/80, to a level higher than the total net output in 1978/79, even if the total area had been irrigated.

TABLE 9 RATES OF RETURN[1/] IN IRR/01 AND IRR/09 OVER TWO YEARS

	Total Costs LS/ha		Total Output LS/ha		Net Output LS/ha		Rate of Return	
	1978/79	1979/80	1978/79	1979/80	1978/79	1979/80	1978/79	1979/80
IRR/01								
Rainfed	634	960	1408	2421	774	1461	122	152
Irrigated	1022	--	2557	--	1535	--	150	--
Total wheat	816	960	1948	2421	1132	1461	139	152
IRR/09								
Rainfed	938	1351	1600	2329	662	977	71	72
Irrigated	1890	1920	3813	4663	1924	2743	102	143
Total wheat	1279	1430	2393	2654	1115	1223	87	86

1/ Rate of return = net output expressed as % of total costs.

In IRR/09, the total net output in 1979/80 would be increased by 516 SL/ha, and the rainfed net output by 253 SL/ha. The farmer sample would have had to irrigate 45 percent of their wheat area in 1978/79 to achieve a net output equal to that of rainfed wheat with prices adjusted to 1979/80 levels:

$$b = \frac{1230 - 662}{1924 - 662}$$

It is of interest to compare the difference in the slopes of the original net outputs in Figure 6 with the difference in the gross output slopes in Figure 3, using the same model:

$NO_1 - NO$ = the increase in net output due to a one percent increase in the irrigated area.

for 1978/79:

$$NO = 0.6415\ (662) + 0.3585\ (1924)$$
$$NO_1 = 0.6315\ (662) + 0.3685\ (1924)$$

and $NO_1 - NO = 12.62$ SL/ha

for 1979/80:

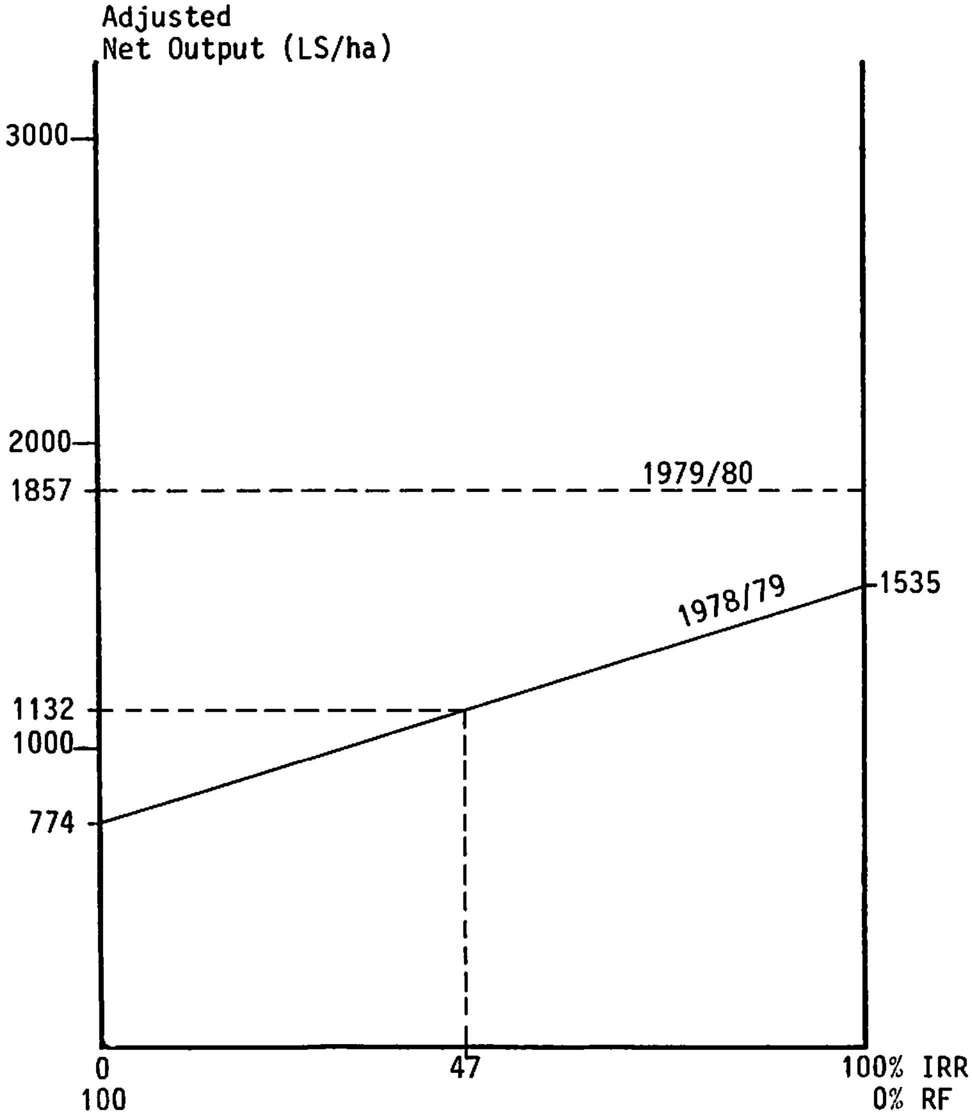
$$NO = 0.8606\ (977) + 0.1392\ (2743)$$
$$NO_1 = 0.8506\ (977) + 0.1492\ (2743)$$

and $NO_1 - NO = 17.67$ SL/ha

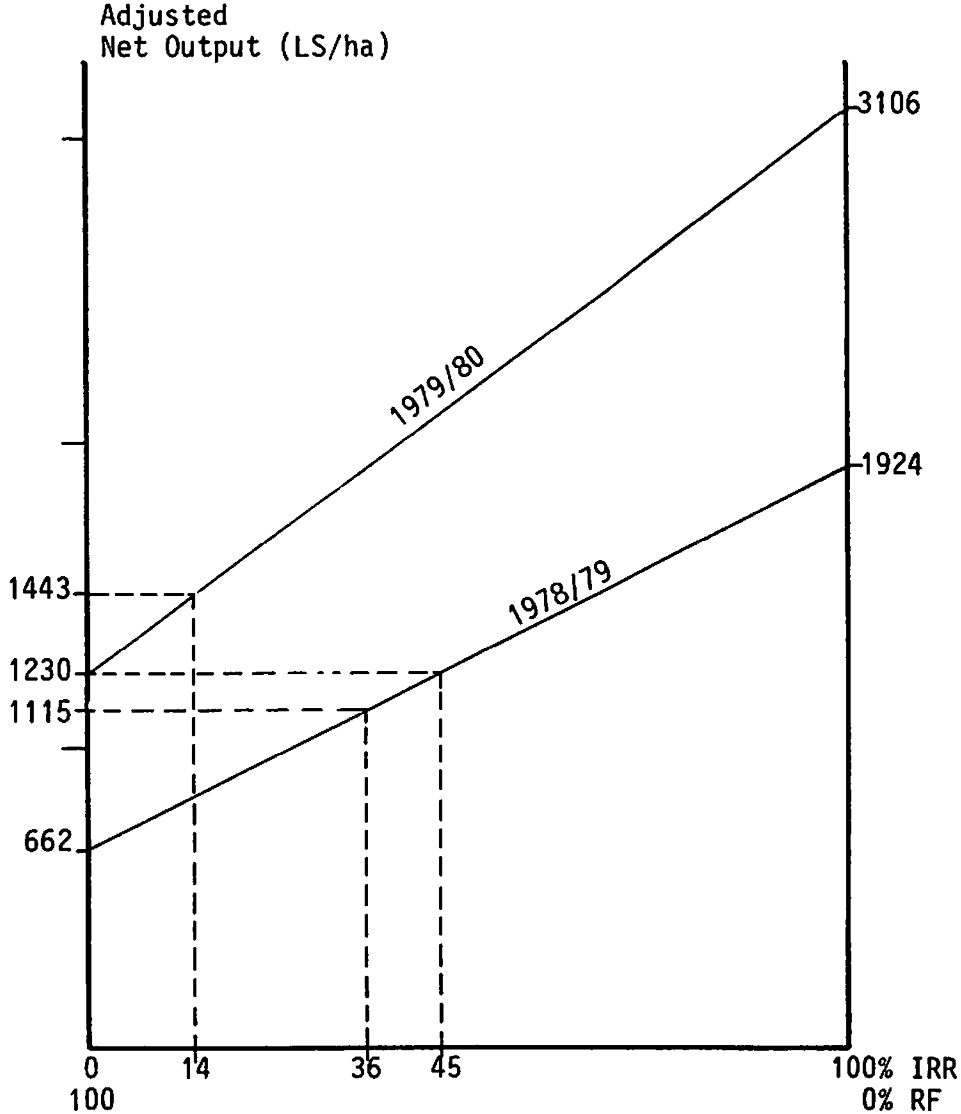
This can also be compared with the adjusted net output slope *for* 1979/80:

$NO_1 - NO = 18.76$ SL/ha

FIGURE 7 NET OUTPUS OF WHEAT ADJUSTED FOR 1978/79 PRICES, ACCORDING TO PROPORTIONAL AREAS UNDER RAINFED AND IRRIGATED WHEAT



IRR/01



IRR/09

The rate of return in terms of net output (SL/ha) to an increase in the proportional area irrigated was higher in 1979/80 than in 1978/79. Furthermore, if the farmers in IRR/09 had irrigated the same area in 1979/80 as in 1978/79, the actual overall net output would have been:

$$NO = 0.6415\ (977) + 0.3585\ (2743)$$
$$= 1610\ SL/ha$$

which is an increase of 387 SL/ha, or 32 percent.

The question remains: why are farmers not irrigating a larger proportion of their wheat in good rainfall years, and thereby increasing their production further?

As already discussed in Section 1, this would not be possible in IRR/01; in 1979/80 the canals remained closed until late April when they were opened for the irrigation of summer crops:cotton, onions, etc.

In IRR/09, where irrigation is from private boreholes, farmers said that in 1979/80 when they intended to irrigate in March, it rained and therefore there was no further need. Only five farmers in the sample irrigated a part of their wheat. Irrigation of wheat does not compete with any other crop for water, but farmers reported that,with increasing fuel costs,it would not be profitable to irrigate in a good rainfall year. They consider that, with irrigation in a poor year they can achieve similar yields to those in a good rainfall year, but that the extra yield achieved by irrigating in a good year would not justify the costs of irrigating. Observing the good rainfall conditions in 1979/80, farmers may have anticipated the lower prices later in the season, due to high regional production, which would further reduce the returns to irrigation. However, this is not supported by the net outputs presented here, which are high for irrigated wheat in 1979/80. However, this statement needs to be viewed cautiously. The calculation of the irrigation component of costs in 1979/80 was rather arbitrary, based as it was on costs (long-term fixed and annual running costs) of the previous year,[1/] allocated according to dunum irrigations in 1979/80. This therefore does not take account of possible cost increases, particularly fuel. However, even if irrigation costs had been doubled in 1979/80, the net output of irrigated wheat would still have been high at 2538 SL/ha.

1/ The costs calculated for 1978/79 cannot be considered as truly accurate. Pumps are a relatively recent introduction to the village, and calculations of such things as costs of repairs, the frequency of breakdowns, and depreciation were difficult.

5. CONCLUSIONS

An underlying permise to this paper is that if similar yields of wheat can be obtained in poor years with supplementary irrigation to those obtained in good rainfed years, then irrigation becomes a risk-reducing strategy for poor rainfall years, securing a constant return of wheat each year. However, it has been shown in this paper that irrigation has only partly fulfilled this role. In a dry year, irrigation was effective in more than doubling yields and therefore has gone someway towards stabilizing production. However, over the two years studied, it was demonstrated that the use of irrigation in a poor year did not compensate for the decrease in yield of rainfed wheat caused by the deficit in rainfall.

Reasons for this are obviously complex, but it would appear that at present, the method of irrigation is not counteracting the effect on yield caused by climatic variables, i.e., rainfall.

FAO advises that "there is a distinct advantage... in having the entire root zone filled to field capacity prior to or soon after sowing to attain optimum root development" (J. Doorenbos and A.H. Kassam, 1979). Irrigation at planting is not possible in IRR/01 as the canals are closed in October. In IRR/09, wheat is planted as soon as possible after the previous crop is harvested. As this is usually cotton, and the land is often not cleared of cotton stalks until November, farmers say they do not have time to prepare the land for an irrigation at planting.

The critical time of water stress in wheat is during the head development and flowering period and FAO continues: "Where rainfall is low and irrigation water supply is limited, in addition to pre-irrigation, applications should be scheduled to avoid water deficits during the flowering period" (Ibid 1979). Farmers, by waiting until March or April before irrigating, would seem to be aware of this.

This paper contains data for two villages over two years only. It must be pointed out that the model developed in this paper is too simplistic to allow firm conclusions to be drawn. It assumes homogeneity between sample farms both within, and across, years. In fact, irrigation is only one factor affecting yields. Others, such as the changing proportions of wheat area on various soil types, variations in fertilizer rates, and the increasing adoption of new, higher yielding varieties, have been mentioned in the text and should be borne in mind when considering the results in this paper. Continued monitoring of both rainfed and irrigated wheat production over good and poor years is needed, and a better understanding of how a farmer makes his decisions with respect to timing and number of irrigations.

One must remember that wheat production is studied in isolation from the rest of the cropping systems in the two villages. Wheat, in IRR/09, is the only winter crop and, by producging large surpluses, is an important cash crop. Its role in IRR/01 is maybe less important. Other winter crops, barley, lentil and vetch are grown for livestock feed and therefore investment is directed towards these crops also.

In 1978/79, net outputs in IRR/09 of 3361 SL/ha from cotton and 5275 SL/ha and 3931 SL/ha from first and second crops of potatoes respectively, were far higher than the net output of 1924 SL/ha from irrigated wheat. In IRR/01, net outputs of 3840 SL/ha on cotton, and 3153 SL/ha on onions, were more than double that from irrigated wheat: 1535 SL/ha. Wheat will have to be able to offer constant and high returns, comparable to those of irrigated crops, before it can attract further investment and irrigation water.

6. REFERENCES

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APPENDIX I RAINFALL 1978/79 AND 1979/80

	1978/79		1979/80	
	IRR/01 (Hama Station)	IRR/09 (Mahardeh)	IRR/01 (Hama)	IRR/09 (Kafr Zeiti)
October	29.5	18.5	59.0	26.0
November	36.5	29.0	39.5	36.0
December	70.8	54.3	114.1	86.8
January	147.3	212.7	126.2	110.5
February	9.5	7.5	53.0	36.5
March	37.6	24.0	109.9	30.9
April	15.7	11.5	101.3	107.3
May	13.0	--	5.0	10.8
June	--	--	--	--
July	--	--	--	--
August	--	--	--	--
September	--	--	--	--
TOTAL	359.9 mm	357.5 mm	608.0 mm	444.8 mm

Source: Provincial Office of MAAR in Hama.

Note: Rainfall figures were taken from the nearest recording station to each village as rain gauges were not installed in the villages until midway through the 1979/80 season.

APPENDIX II RAINFED WHEAT YIELD (kg/ha) ACCORDING TO VARIETY AND SOIL TYPE IRR/01 AND IRR/09 - 1978/79

Village / Soil Type	IRR/01 1	IRR/01 2	IRR/01 3	IRR/09 1	IRR/09 2	IRR/09 3
Local (Bayadi)	--	--	1500*	--	--	--
Mexipak	1175 (287.6) 1/	1163 (362.9)	625*	1894 (131.9)	1408 (479.8)	1201 (273.8)
Florence Aurore	--	--	--	--	1247 (221.1)	--
Italian (Senator Capelli)	1153 (112.3)	1750*	--	1458*	--	--
Jori	986 (50.9)	--	--	--	--	--
Georgette	--	--	--	--	--	--

IRRIGATED WHEAT YIELD (kg/ha) ACCORDING TO VARIETY AND SOIL TYPE IRR/01 AND IRR/09 1978/79

Village / Soil Type	IRR/01 1	IRR/01 2	IRR/01 3	IRR/09 1	IRR/09 2	IRR/09 3
Local (Bayadi)	--	--	2500*	--	--	--
Mexipak	1686 (785.7)	--	--	4038 (641.0)	--	--
Florence Aurore	--	--	--	--	--	--
Italian (Senator Capelli)	2444 (1167.7)	--	--	--	--	--
Jori	2799 (951.3)	2238 (839)	1000*	--	--	--
Georgette	--	1250*	--	6250*	--	--

* One plot only.

1/ Standard Deviations are given in parantheses.

APPENDIX III RAINFED WHEAT YIELDS (kg/ha) BY VARIETY AND SOIL TYPE IRR/01 AND IRR/09 - 1979/80

Village / Soil Type	IRR/01 1	IRR/01 2	IRR/01 3	IRR/09 1	IRR/09 2	IRR/09 3
Local (Bayadi)	--	--	1667*	2615 (313.2)	2514 (1646.0)	1953*
Mexipak	2743 (1033.4)[1/]	2230 (363.0)	2188*	3023 (758.6)	2254 (528.1)	2177 (580.4)
Florence Aurore	--	--	--	--	--	--
Italian (Senator Capelli)	1868 (777.7)	1642 (568.5)	2000*	--	--	--
Jori	3042 (749.6)	2997 (833.0)	2500*	4038 (995.8)	3188 (2163.0)	--
Georgette	4386 (1120.1)	3394 (639.9)	--	4465 (757.3)	--	--
Jezireh 17	3580 (241.1)	2500*	--	3355*	--	--
Stork	5000 (0)	4500*	--	6042 (1804.2)	--	--

IRRIGATED WHEAT YIELDS (kg/ha) BY VARIETY AND SOIL TYPE IRR/01 AND IRR/09 - 1979/80

Village / Soil Type	IRR/01	IRR/09 1	IRR/09 2	IRR/09 3
Florence Aurore	NO IRRIGATION	--	2188*	--
Jori		--	4762*	--
Georgette		5948 (1749.8)	--	--
Jezireh 17		4981 (27.6)	--	--

* One plot only.

1/ Standard Deviations are given in parantheses.

APPENDIX IV PHYSICAL FLOWS (kg) FOR 1978/79 AND 1979/80 - IRR/01 AND IRR/09

	IRR/01				IRR/09			
	1978/79		1979/80		1978/79		1979/80	
	Total	/ha	Total	/ha	Total	/ha	Total	/ha
START STOCK	7013	162	5088	143	11231	157	13019	151
+ Purchased	2131	49	3455	97	3750	53	6736	78
- Consumed	9144	212	8543	239	14981	210	19755	229
HARVEST	75877	1756	98677	2764	179800	2518	280786	3257
Transfer to Combine	187	4	1	1	10625	149	22094	256
Rent	6287	146	6719	188	18780	263	35127	408
Gift	125	3	2125	60	8312	116	14062	163
Sale	30790	713	42846	1200	101704	1424	172284	1999
Transfer to Livestock	6688	155	5625	158	500	7	--	--
Transfer to Household	23462	543	37487	1050	29566	414	25781	299
END STOCK	8338	193	3875	109	10313	144	11438	133
Area (ha)	43.2		35.7		71.4		86.2	
Δ Flows	+35258	+816	+48235	+1351	+135671	+1900	+236831	+2747
Δ Stocks	+1325	+31	-1213	-34	-918	-13	-1581	-18
Δ System	+36583	+847	+47022	+1317	+134753	+1887	+235250	+2729

APPENDIX V EXAMPLE OF AN INDIVIDUAL ADJUSTED WHEAT FLOW

VILLAGE IRR/09 - FARMER No. 3

	1978/79		1979/80	
	Actual	Adjusted	Actual	Adjusted
Area under wheat (ha)	5.0		7.8	
Mean rainfed yield (kg/ha)	1062.5		3429.0	
Mean rainfed seed rate (kg/ha)	150.0		270.0	
Seed -- stock	925	925	1695	1695
purchased	--	--	--	411 1/
used	925	750	1695	2106
Harvest	13750	5313	39015	26746
-- combine harvester	875	338	3125	2142
rent	--	--	4375	2999
gifts	1250	483	2375	1628
sale	7500	542	26640	17477
livestock	--	--	--	--
household	2125	2125	1875	1875
END STOCK	2000	2000	625	625
Δ Flow	+9625	+1373	+36515	+23835
Δ Stock	+1075	+1075	-1070	-1070
Δ System	+10700	+2448	+35445	+22765
Adjusted Δ System - Actual Δ System		-8252		-12680

1/ Further seed would have to be purchased, since, in this case, the mean rainfed seed rate is higher than the irrigated seed rate.

APPENDIX VI "ADJUSTED" PHYSICAL FLOWS 1978/79 AND 1979/80 IRR/01 AND IRR/09

	IRR/01				IRR/09			
	1978/79		1979/80		1978/79		1979/80	
	Total	/ha	Total	/ha 1/	Total	/ha	Total	/ha
START STOCK	7013	162	5088	143	11231	157	13019	151
+ Purchased	1696	39	3455	97	2842	40	7001	81
- Consumed	8709	202	8543	239	14073	197	20020	232
HARVEST	50432	1167	98677	2764	104951	1470	255661	2966
Transfer to Combine	124	3	0	0	6202	87	20117	233
Rent	4179	97	6719	188	10962	154	31984	371
Gift	83	2	2125	60	4852	68	12804	149
Sale	7558	175	42846	1200	42556	596	153537	1781
Livestock	6688	155	5625	158	500	7	0	0
Household	23462	543	37487	1050	29566	414	25781	299
END STOCK	8338	193	3875	109	10313	144	11438	133
Area (ha)	43.2		35.7		71.4		86.2	
Δ Flows	+10248	+237	+48235	+1351	+61730	+865	+211441	+2453
Δ Stocks	+1325	+31	+1213	-34	-918	-13	-1581	-18
Δ Systems	+11573	+268	+47022	+1317	+60812	+852	+209860	+2435

1/ IRR/01, 1979/80 wheat flow remains unadjusted as all wheat was rainfed.

APPENDIX VII IRR/01 - COMPONENTS OF NET OUTPUT (LS/ha) FOR AGGREGATE FARMER SAMPLE 1978/79 AND 1979/80

	1978/79			1979/80		
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Rainfed Wheat	Irrigated Wheat	Total Wheat
OPENING VALUATION	212	170	192	164	--	164
+ Expenditure	274	562	409	553	--	553
+ Machinery charge (inc. combine)	24	74	48	87	--	87
+ Transfer from Livestock (manure)	4	2	2	0	--	0
+ Rent	118	190	152	156	--	156
+ Irrigation	0	26	12	0	--	0
= TOTAL COSTS	634	1022	816	960	--	960
INCOME	89	1039	535	1022	--	1022
+ Transfers to livestock feed (inc. straw)	191	632	398	237	--	237
+ Transfer to household	771	413	603	860	--	860
+ Other disposals (rent, gifts, etc.)	127	214	168	210	--	210
+ Closing valuation	228	262	244	92	--	92
= TOTAL OUTPUT	1408	2557	1948	2421	--	2421
OUTPUT - COST = NET OUTPUT	774	1535	1132	1461	--	1461
Area (ha)	22.9	20.3	43.2	35.7	0	35.7

APPENDIX VIII IRR/09 - COMPONENTS OF NET OUTPUT (LS/ha) FOR AGGREGATE FARMER SAMPLE 1978/79 AND 1979/80

	1978/79			1979/80		
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Rainfed Wheat	Irrigated Wheat	Total Wheat
OPENING VALUATION	216	268	235	266	254	264
+ Expenditure	400	748	525	561	757	588
+ Machinery charge (inc. combine)	124	293	185	186	433	220
+ Transfer from livestock (manure)	0	0	0	0	0	0
+ Rent	198	453	289	339	271	330
+ Irrigation	0	127	46	0	205	29
= TOTAL COSTS	938	1890	1279	1351	1920	1430
INCOME	447	2248	1093	1353	3227	1614
+ Transfer to livestock feeds (inc. straw)	35	301	131	0	0	0
+ Transfer to household	522	334	454	241	298	249
+ Other disposals (rent, gifts, etc.)	427	808	564	655	638	652
+ Closing valuation	165	124	150	80	500	139
= TOTAL OUTPUT	1600	3813	2393	2329	4663	2654
OUTPUT - COST = NET OUTPUT	662	1924	1115	977	2743	1223
Area (ha)	45.8	25.6	71.4	74.2	12.0	86.2

APPENDIX IX COMPONENTS OF NET OUTPUT AS % OF NET OUTPUT IRR/01 AND IRR/09 OVER TWO YEARS

	1978/79			1979/80		
	Rainfed Wheat	Irrigated Wheat	Total Wheat	Rainfed Wheat	Irrigated Wheat	Total Wheat
IRR/01						
Opening and closing valuation balance	+2.1	+6.0	+4.6	-4.9	--	-4.9
Expenditure/income balance	-23.9	+31.1	+11.1	+32.1	--	+32.1
Machinery charge	-3.1	-4.8	-4.2	-6.0	--	-6.0
Rent	-15.2	-12.4	-13.4	-10.7	--	-10.7
Irrigation	0	-1.7	-1.1	0	--	0
Transfer to livestock	+24.7	+41.2	+35.2	+16.2	--	+16.2
Transfer to household	+99.6	+26.9	+53.3	+58.9	--	+58.9
Other disposals	+16.4	+13.9	+14.8	+14.4	--	+14.4
IRR/09						
Opening and closing valuation balance	-7.7	-7.5	-7.6	-19.0	+9.0	-10.2
Expenditure/income balance	+7.1	+78.0	+50.9	+81.1	+90.0	+83.9
Machinery charge	-18.7	-15.2	-16.6	-19.0	-15.8	-18.0
Rent	-29.9	-23.5	-25.9	-34.7	-9.9	-27.0
Irrigation	0	-6.6	-4.1	0	-7.5	-2.4
Transfer to livestock	+5.3	+15.6	+11.7	0	0	0
Transfer to household	+78.9	+17.4	+40.7	+24.7	+10.9	+20.4
Other disposals	+64.5	+42.0	+50.7	+67.0	+23.3	+53.3

APPENDIX X COMPONENTS OF NET OUTPUT (LS/ha) FOR 1979/80 ADJUSTED TO 1978/79 PRICES FOR WHEAT[1/]

	IRR/01			IRR/09		
	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total
Opening valuation	164	--	164	266	254	264
Expenditure	553	--	553	561	757	588
Machinery charge	87	--	87	186	433	220
FYM	0	--	0	0	0	0
Rent	203	--	203	480	350	462
Irrigation	0	--	0	0	205	29
TOTAL COSTS	1007	--	1007	1493	1999	1563
Income	1022	--	1022	1353	3227	1614
Transfer to livestock	312	--	312	0	0	0
Transfer to household	1158	--	1158	339	405	348
Other disposals	273	--	273	923	825	910
Closing valuation	119	--	119	108	648	184
TOTAL OUTPUT	2864	--	2864	2723	5105	3056
NET OUTPUT	1857	--	1857	1230	3106	1493

1/ 1979/80 prices for wheat were: Durum SL 0.85/kg; Bread wheat SL 0.75/kg. Opening valuation, expenditure, machinery charge, FYM, irrigation and income remain the same.

All physical transfers: rent in kind, transfer to livestock feed and household, other disposals and closing valuation are all revalued at 1978/79 prices of SL 1.10/kg.