Ministry of Water and Irrigation
Jordan Valley Authority
Reclaimed Water Project

Economic Aspects of the Use of Reclaimed Water in Irrigated Agriculture in the Jordan Valley

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Abbreviations and Acronyms

AHT GROUP AG	Consultant
DA	Development Area
dS	deci-Siemens
du	dunum (0.1 ha)
EC_e	soil salinity
EC_{iw}	irrigation water salinity
FU	farm unit
g	gram
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (German Technical Cooperation)
ID	crop identification number
JD	Jordanian Dinar
JVA	Jordan Valley Authority
K	potassium
KAC	King Abdullah Canal
KfW	Kreditanstalt für Wiederaufbau (German Financial Cooperation)
kg	kilogram

KTR	King Talal Reservoir
l	litre
m^3	cubic meter
MCM	million cubic metres
ml	millilitre
mm	millimetre
N	nitrogen
NCARTT	National Centre for Agricultural Research and Technology Transfer
OF	open field
P	phosphorus
PH	plastic house
RW	reclaimed water
RWP	Reclaimed Water Project
Std. Dev.	standard deviation
TWW	treated wastewater
WWTP	wastewater treatment plant

1 Introduction

The Reclaimed Water Project (RWP) is jointly implemented by the Jordan Valley Authority (JVA) and German Technical Cooperation (GTZ). The agricultural component of the project focuses on the use of reclaimed water for irrigation in the middle and southern Jordan Valley. The preparation of "Guidelines for Reclaimed Water Use in Irrigated Agriculture in the Jordan Valley" (hereinafter called RW Guidelines) is a key component of the RWP. In the context of the RWP, the economic aspects of the use of reclaimed and marginal water in agriculture were assessed and evaluated during a mission that took place from 19 – 31 March 2006. The corresponding Terms of Reference as well as a mission calendar are attached in Annex A to this report.

Over two years, from July 2003 to July 2005, RWP staff visited more than 20 farm units (FU) in the middle and southern Jordan Valley on a regular basis. The ~~study~~ team collected data for 55 crop cycles at various fields during the cropping seasons of 2003/4 and 2004/5. The agricultural and irrigation practices were intensively monitored and recorded. Data gathered included tillage and seedbed preparation data, transplanting and harvesting data, irrigation and fertilization data specifying the quantities of water and nutrients applied to the various crops, and soil laboratory analysis for selected fields. The on-field data were complemented with data collected from other sources. Water quality data and meteorological data were obtained from the Jordan Valley Authority (JVA) and the National Centre for Agricultural Research and Technology Transfer (NCARTT), and a survey on fertiliser availability, fertiliser types and the costs of various multi-nutrient and straight fertilisers was conducted in 2003. Furthermore, data and information on crop management practices like permanent and seasonal labour use and cost, machinery use, fuel and or electricity cost were gathered on site in 2006, and the Ministry of Agriculture provided RWP with monthly market information data (prices and quantities sold) for different crops for the years 2003 and 2004 as well as yearly average prices for a number of crops for the period 2000 – 2005.

Based on the analysis of the available information, and in cooperation with RWP staff the present report was prepared. Its purpose is to look at agricultural production and more specifically at the use of reclaimed water in irrigated agriculture, from an economic perspective. The underlying two core questions are:

1. Which crops appear to have an (economic) advantage in agricultural production in the Southern and Middle Jordan Valley, and how do plastic house and open field production compare from an economic point of view?

2. What is the economic effect of the use of reclaimed water – and of adapted crop management practices – at the farm level (crop gross margin and net margin) as well as at the aggregated level?

Furthermore, the use of brackish (saline) water was assessed under economic aspects.

The information presented in this report will serve farmers and agricultural extension agents in improving agricultural production in the Jordan Valley, as the use of reclaimed water will be extended in the future and farmers will strive to make appropriate profits so as to ensure their families' well-being and gradual improvement of living standards.

2 Background and Methodology

2.1 Background

The theoretical background of the RWP is the development of alternative concepts and dissemination of applicable extension material for agricultural practices under irrigation with reclaimed water. The objectives are to

- **evaluate** the fertigation and irrigation practices of farm units and main crops in the Jordan Valley under consideration of the nutrient content of the reclaimed water and
- **establish** practical recommendations for fertigation and irrigation management for the most important crops grown in the Jordan Valley.

2.2 Methodology

The economic analysis is mainly based on farm data that were collected by the RWP team on 51 representative fields, located in the DAs 20 to 29, representing seven main crops (tomato, eggplant, sweet pepper, squash, okra, cucumber and date palm). The previously established agronomic analysis of crop management practices had led to the establishment of proposals for an optimisation of irrigation and fertilisation on these fields. Current and proposed practices are presented in the RW Guidelines that were taken as a major information source for the preparation of the present report.

Agricultural input and output prices were compiled so as to establish a sound data basis on which the calculation of gross and net margins as well as other economic indicators could then be based (see chapter 3 for details).

2.2.1 Gross Margins and Economic Indicators

Gross margins were calculated by deducting from a crop's gross return (sales value, i.e. economic valuation of all harvested marketable plant parts) its variable production cost, which comprises costs for

- Seeds/seedlings
- Fertiliser
- Manure
- Pesticides
- Mulch
- Energy
- Machinery
- Seasonal labour
- Water
- Transport & packaging.

EQUATION 1: GROSS MARGIN = NET RETURN – VARIABLE COST

The result of diminishing the gross margin of a specific crop by its attributable share of the farm's total fixed cost is its net margin. Fixed cost comprises

- Permanent labour
- Depreciation of irrigation equipment
- Depreciation of plastic houses and other investment
- Depreciation of plantation
- Land rent.

EQUATION 2:	NET MARGIN	= GROSS MARGIN – FIXED COST

While these two performance indicators are the most important economic ones for farmers (and thus also for extension agents) in taking crop production and management decisions, other indicators were calculated and compared as well; these indicators comprise

- Productivity indicators
- Profitability indicators
- Efficiency indicators (physical and financial).

It has to be noted that the indicators which will be explained in the following and which are an integral part of the later chapters must not be seen as valid over a stretch of input levels or over a longer period of time; they may change from year to year, and they will certainly change with increased or decreased input quantities. Thus, they can only present a current status and will have to be evaluated on a regular basis so as to allow for timely conclusions and, potentially, decisions.

Two productivity indicators were calculated which are **yield per m³ irrigation water** supplied to the crop (i.e. not only the part evapo-transpirated by the plant but the crop's share of the total quantity delivered to the farm unit) and **yield per total kg N supplied** (with N as the major plant nutrient; indicators for P and K may be calculated similarly). The underlying equation for either input is

$$\text{EQUATION 3: YIELD PER UNIT INPUT “A”} = \frac{\text{TOTAL YIELD (KG)}}{\text{QUANTITY OF INPUT “A” (M}^3\text{ OR KG)}}$$

The indicator is thus measured in kg/kg or kg/m³ or similar units. Productivity indicators can be mainly used for intra-FU comparison, e.g. based on a time series of production data to see how one indicator has developed over a number of years and whether any conclusions can be drawn (horizontal comparison). Such indicators can also be helpful in comparing crop management practices of one crop on different farms (vertical comparison). Productivity indicators may not be used for comparison of different crops.

The available data did not allow for the establishment of a production function that considers the factors N-fertilisation and irrigation. This in consequence means that a sophisticated and precise analysis towards the optimum specific factor intensity was not feasible. Instead, data from the different FUs were used to calculate comparative profitability indicators with regard to irrigation and fertilisation, so as to give way to the formulation of a trend with regard to a better use of the two factors, thus leading to a more efficient allocation of resources within the production process.

In addition to gross and net margins, two profitability indicators were calculated which are **output per m³ irrigation water** supplied to the crop (again, not only the part evapo-transpirated by the plant but the crop's share of the total quantity delivered to the farm unit) and **output per kg N from chemical fertiliser**. The underlying equation for either input is

$$\text{EQUATION 4: OUTPUT PER UNIT INPUT “A”} = \frac{\text{GROSS MARGIN (JD)+ COST OF INPUT “A” (JD)}}{\text{QUANTITY OF INPUT “A” (M}^3\text{ OR KG)}}$$

The indicator is thus measured in JD/kg or JD/m³ or similar units. Profitability indicators allow for the comparison of FUs and of different crops, they can thus help to reveal strengths or flaws of certain crops in a specific local context. Although these indicators may be less interesting to farmers, they can be the more helpful for decision makers as they represent the average revenue per unit of this input. In fact, they show at which price for input "A" the gross margin of the examined crop would become zero (under the "ceteris paribus"-assumption, i.e. the assumption that the use of all other production factors is kept constant as well as all other input and output prices).

The calculated financial irrigation water use efficiency indicator is the ratio of irrigation water use per JD net margin (again, irrigation water supplied to the crop, see above). The underlying equation is

EQUATION 5: IRRIGATION WATER USE EFFICIENCY=	NET MARGIN (JD) / IRRIGATION WATER SUPPLIED M³

The indicator is thus measured in JD/m³. This indicator is of mostly political/macro-economic interest as it allows a comparison of different productive sectors of an economy with regard to the added value of one m³ of water.

2.2.2 Economic Value of Reclaimed Water

The economic value of reclaimed water was assessed at two levels, i.e. the farm level and the aggregated level (project area as supplied with treated wastewater (TWW) by wastewater treatment plant (WWTP) Khirbet As Samra).

As this WWTP supplies TWW to the Southern part of King Abdullah Canal (KAC-South) and to King Talal Reservoir (KTR), the respective water inflows from these two sources into the related Development Areas (DAs) were used for calculation purposes as shown in the table below. Furthermore, an overall conveyance efficiency of 90% was assumed.

Table 1 Basic Data for Assessing the Value of Nutrient Contents in Irrigation Water

	KAC-South	KTR	Total
Inflow (MCM)	41.34	46.94	88.28
Conveyance efficiency		90%	
N fertigation efficiency		80%	
P fertigation efficiency		90%	
K fertigation efficiency		90%	

Source: RWP; KfW-financed feasibility study on reuse of TWW in the Northern Jordan Valley, 2005

Inflow and conveyance efficiency were used to calculate available irrigation water quantities at the farm gate level. These quantities were then computed into effective N-, P- and K-contents with the help of mean NH_4 volatilisation and fertigation efficiency rates as found in the "RW Guidelines", and under the assumption that irrigation takes place during nine out of twelve months per year. Effective contents were then valued at average straight N, P and K fertiliser prices as established earlier during the RWP (see Table 4 for details).

EQUATION 6: TOTAL EFFECTIVE N-CONTENT IN IRRIGATION WATER=	[NO_3-N-CONTENT (g/m³) x FERTIGATION EFFICIENCY +NH_4-N-CONTENT x (1-VOLATILISATION RATE)] x INFLOW (m³) x CONVEYANCE EFFICIENCY x 0.75

EQUATION 7:	TOTAL EFFECTIVE P-CONTENT IN IRRIGATION WATER=	[PO_4-P-CONTENT (g/m^3) x FERTIGATION EFFICIENCY] x INFLOW (m^3) x CONVEYANCE EFFICIENCY x 0.75

EQUATION 8:	TOTAL EFFECTIVE K-CONTENT IN IRRIGATION WATER=	[K-CONTENT (g/m^3) x FERTIGATION EFFICIENCY] x INFLOW (m^3) x CONVEYANCE EFFICIENCY x 0.75

EQUATION 9:	VALUE OF TOTAL EFFECTIVE CONTENT OF NUTRIENT "A" IN IRRIGATION WATER=	TOTAL EFFECTIVE CONTENT OF NUTRIENT "A" (KG) X UNIT PRICE OF NUTRIENT "A" IN STRAIGHT FERTILISER (JD/KG)

For the present situation, nutrient contents as measured and averaged over a number of samples were taken from the RW Guidelines. These contents were compared to the contents measured in TWW effluent at WWTP Khirbet As Samra in 2003, and rough dilution factors were thus calculated to have an idea about the change in nutrient content that TWW undergoes from source (WWTP) to sink (DAs) in the RWP area.

Assuming that after rehabilitation/extension of WWTP Khirbet As Samra the N, P and K content of the effluent would conform to the norms stipulated in the Jordanian Standard JS893/2002, these dilution factors were applied to the effluent content, together with volatilisation and fertigation efficiency rates as briefly presented above, to arrive at an approximation of effective nutrient contents after rehabilitation/extension. Again, an irrigation period of nine months per year was assumed.

In this manner, the tendency in the development of the physical (quantities) and financial (nutrient value) importance of nutrients in reclaimed water for irrigation can be presented, although it has to be noted that figures as presented in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** have to be considered as approximate values which will need verification with regard to their physical components (reclaimed water quantities and nutrient contents) and updating of nutrient prices once WWTP Khirbet As Samra is operational.

2.2.3 Economic Value of Brackish Water

As stipulated in the Terms of Reference, a "threshold/slope" model was set up with regard to the impact of salinity in irrigation water. Information as found in literature and in recent studies and guidelines for the Jordan Valley on agronomic effects of salinity in irrigation water was compiled and computed to evaluate salinity contents in economic terms.

The economic influence of brackish water, i.e. the impact of irrigation water salinity, was assessed with the help of information found in the "Guidelines for Brackish Water Irrigation in the Jordan Valley (GTZ 2003) as well as in the KfW-financed feasibility study on reuse of TWW in the Northern Jordan Valley (GITEC/AHT/CEC 2005).

A computational basis for this assessment was the equation presented in GTZ's "Brackish Water Guidelines":

EQUATION 10:	EC_e=	1.5 x EC_{iw}

3 Basic Considerations

Basic considerations as well as input and output prices as compiled for the purpose of this report are presented in this chapter.

In the context of this report, long season crops are tomato, cucumber, potato, eggplant and sweet pepper. Short season crops are leaf crops, squash, sweet corn, out of which only squash figures in this report.

The abbreviation "OF" denotes open field production whereas "PH" means that production takes place in a plastic house (in general about 0.5 du per PH).

"Current practice" stands for the way that farmers presently manage their crops (mainly with regard to irrigation and fertilisation) whereas "proposed practice" refers to the agronomic recommendations as presented for the different crops and FUs in the RW Guidelines.

3.1 Market Prices

Transportation and packaging have to be deducted to receive farm gate prices (see points 7. and 8.). In gross margin and calculations, market prices have been applied and transport/packaging have been treated as variable cost.

Date price is price of exported goods.

Table 2 Market Prices for Agricultural Products

Cucumber	0.210	JD/kg
Eggplant		
Classic	0.142	JD/kg
Ajami	0.129	JD/kg
Okra	0.939	JD/kg
Squash	0.213	JD/kg
Date palm	2.000	JD/kg
Sweet pepper	0.258	JD/kg
Tomato	0.134	JD/kg

Source: Ministry of Agriculture; 2000-2005 averages

3.2 Variable Cost

3.2.1 Cost of Seeds/Seedlings

Cost for transplantation of seedlings is included here. It can be noted that the cost of tomato and eggplant seedlings for PH production is remarkably higher than for OF production while both are at bout the same level for sweet pepper.

Table 3 Unit Cost of Seeds/Seedlings of Different Crops

Open field		
Eggplant	24.000	JD/du
Okra	15.000	JD/du
Squash	11.100	JD/du
Sweet corn	6.100	JD/du
Sweet pepper	50.000	JD/du
Tomato	48.000	JD/du
Plastic house		
Cucumber	130.000	JD/du
Eggplant	90.000	JD/du

Sweet pepper	55.000	JD/du
Tomato	75.000	JD/du

3.2.2 Manure and Fertiliser

Cost of manure (chicken, cattle, fermented) varies between 20 and 25 JD/ton. An average of 22 JD/ton was assumed here.

Fertiliser cost was calculated at an earlier stage of the RWP from actual average prices for multinutrient and straight fertilisers.

Other fertilisers (micro.nutrients, soil amendments) are assumed to present a cost of 20% of the total cost of N, P and K fertilisers.

Table 4 Unit Cost of Manure and Chemical Fertilisers (as per kg of Nutrient)

Chicken manure	22.000	JD/ton
Multinutrient fertiliser, average		
N	1.719	JD/kg
P	3.906	JD/kg
K	2.071	JD/kg
Straight fertiliser, average		
N	0.644	JD/kg
P	1.373	JD/kg
K	0.843	JD/kg
Other chemical fertilisers	(20% of NPK cost)	

3.2.3 Pesticides and Mulch

All crops in PH ("protected crops") are sprayed intensively (10 to 12 times per season at an average cost of 7 JD per application).

As a rule of thumb, it can be assumed that phytosanitary measures in OF long season crops on average cost 45 JD/du; plant protection in OF short season crops on average costs 50% of that in OF long season crops.

Cost of machinery use for spraying is included.

Table 5 Unit Cost of Pesticides and Mulch

Pesticides		
Plastic house	160.000	JD/du
Open field long season crop	45.000	JD/du
Open field short season crop	22.500	JD/du
Black plastic mulch	15.000	JD/du

3.2.4 Packaging and Transport

For simplicity reasons, it is assumed in subsequent calculations that OF farmers use new and second hand boxes at a rate of 50% each (unit cost 0.165 JD/box). PH farmers only use new boxes.

In most cases transport is assigned to truck owners/drivers. Related cost is assumed to be generally applicable. Transport to Amman costs 0.100 JD/box, transport to a market in the Jordan Valley 0.060 JD/box. Therefore, an average of 0.080 JD/box was assumed in subsequent calculations

Table 6 Unit Cost of Transport and Packaging

Packaging		
New polystyrene boxes	0.220	JD/pc

Second hand polystyrene boxes	0.110	JD/pc
Average transportation cost	0.080	JD/box

3.2.5 Machinery Use and Labour

For simplicity reasons, a rate of 500 JD/du for labour is assumed for each crop in PH production, 30% of which is seasonal labour.

For OF production, the assumed rate is 100 JD/du for each crop except Okra, with 60% for seasonal labour. The rate for Okra is 200 JD/du because of higher labour requirements in harvest (supplement added to seasonal cost). The rate for date palm was assumed to be 200 JD/du as well.

Machinery use comprises soil preparation and incorporation of manure (ploughing/chiselling and harrowing in general).

Table 7 Unit Cost of Machinery Use and Seasonal Labour

Machinery use		
Open field	12.000	JD/du
Plastic house	20.000	JD/du
Seasonal labour		
Plastic house	150.000	JD/du
Open field long season crop	60.000	JD/du
Open field short season crop	60.000	JD/du
Okra	200	JD/du
Date palm	200	JD/du

3.2.6 Water and Energy

JVA's average water charges currently are 0.015 JD/m³. Fuel/electricity cost for pumping is based on a total energy cost of 300 JD/FU (according to farmers' estimations) for an average FU size of 30 du and a cultivation index of 1.4.

Table 8 Unit Cost of Irrigation Water and Energy

JVA irrigation water charges	0.015	JD/m³
Fuel/electricity	7.143	JD/du

3.3 Fixed Cost

3.3.1 Depreciation

According to information from the KfW-financed Feasibility Study "Reuse of Treated Wastewater in the Northern Jordan Valley" (2005), planting cost for a date palm plantation is 125 JD/du; with a lifetime of 25 years, the annual "depreciation" is thus 5 JD/du/year.

Calculated depreciation of equipment is based on an average of 30 du per FU and a cultivation index of 1.4.

Investment cost for a water pond is 400 JD, the lifetime is assumed to be 15 years.

Investment cost for a PH metal structure (new) is 1,300 JD per PH (2,600 JD/du); lifetime is 25 years. The plastic cover requires an investment of 300 JD/PH (600 JD/du) and has a lifetime of 3 years.

Apart from pond and pump, the irrigation equipment consists of laterals (investment cost: OF 50 JD/du; PH 70 JD/du; lifetime 3 years) and main and submain lines (investment cost: OF and PH 80 JD/du; lifetime 12 years).

Table 9 Depreciation of Fixed Assets

Date palm plantation	5.000	JD/du/year
Pond	0.635	JD/du/year
Pumping equipment	0.952	JD/du/year
Plastic house		
Metal structure	74.286	JD/du/year
Plastic cover	142.857	JD/du/year
Irrigation equipment	28.095	JD/du/year
Open field		
Irrigation equipment	16.667	JD/du/year

3.3.2 Permanent Labour

For simplicity reasons, a rate of 500 JD/du for labour is assumed for each crop in PH production, 70% of which is permanent labour.

For OF production, the assumed rate is 100 JD/du for each crop with 40% for permanent labour. The exception is date palm where permanent labour was assumed to cost 200 JD/du.

Table 10 Cost of Permanent Labour

Plastic house	350.000	JD/du
Open field long season crop	40.000	JD/du
Open field short season crop	40.000	JD/du
Date palm	200.000	JD/du

3.3.3 Land Rent

Land rent rates differ between DAs. For DAs 26 to 28, a rate of 1,500 JD to 2,000 JD per FU of 35 ha net cultivated area was assumed, as well as a cultivation index of 1.4.

For DAs 20 to 23, a rate of 2,500 JD to 3,500 JD per FU of 30 ha net cultivated area was assumed as well as a cultivation index of 1.4.

Table 11 Cost of Seeds/Seedlings of Different Crops

DAs 26, 27, 28 (16)	39.286	JD/du
DAs 20, 21, 22, 23 (17)	78.571	JD/du

4 Gross Margins and Net Margins of Different Crops

The following chapters contain information on gross and net margins of the examined crops. The respective calculations are presented in an exemplary manner for three crops – current and proposed practice – in Annex B[1]. Overviews for all examined crops and FUs are presented in this Annex as well.

4.1 Tomato

Tomato is grown both in open fields and in plastic houses. The features of both cultivation practices are remarkably different.

4.1.1 Open Field

Table 12 shows that the average tomato yield is 7.7 tons/du; however, an important standard deviation as well as the remarkable yield differences between FUs producing the same variety illustrate that full production potential may not have been tapped yet in all cases.

Table 12 Tomato Open Field: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Variable Cost Proposed Practice
		kg/du	JD/du	JD/du	JD/du
09-27_344	GS	6,745	902	475	440
15-23_187	Oscar	4,389	587	342	337
33-29_011	Sina 5019	12,672	1,694	634	658
38-20_081	Wafa	2,980	398	318	329
39-22_248	Oscar	16,393	2,191	716	793
27-28_061	Wafa	7,448	996	490	443
67-28_313	GS	4,410	589	386	372
75-29_011	Sheifa	6,400	855	425	422
	Average	7,680	1,027	473	474
	Std. Dev.	4,287	573	131	154

The following Figure 1 clearly indicates that in both current and proposed practice deviations from the average gross margin are large; this is due to the fact that the specific yields are assumed to remain stable when shifting from current to proposed practice[2].

Table 13 then presents gross and net margins of open field tomato production. Again, large standard deviations can be noted, and while two FUs reach gross margins of more than 1,000 JD/du, one FU produces with a gross margin of less than 100 JD/du; in the latter case, net margin is negative (the farmer loses money in tomato production in the examined season).

[1] The complete set of 102 calculations figures in the Annex of the electronic version of the present report; for reasons of complexity, they were omitted in the printed version.

[2] This reasoning is the same for all examined crops.

Table 13 Tomato Open Field: Gross and Net Margins

		Gross Margin		Net Margin	
		Current Practice	Proposed Practice	Current Practice	Proposed Practice
	Variety	JD/du	JD/du	JD/du	JD/du
09-27_344	GS	427	461	330	364
15-23_187	Oscar	245	250	108	113
33-29_011	Sina 5019	1,059	1,036	962	938
38-20_081	Wafa	80	69	-57	-68
39-22_248	Oscar	1,475	1,398	1,338	1,261
27-28_061	Wafa	506	553	408	455
67-28_313	GS	203	218	106	120
75-29_011	Sheifa	430	434	332	336
	Average	553	552	441	440
	Std. Dev.	445	420	443	419

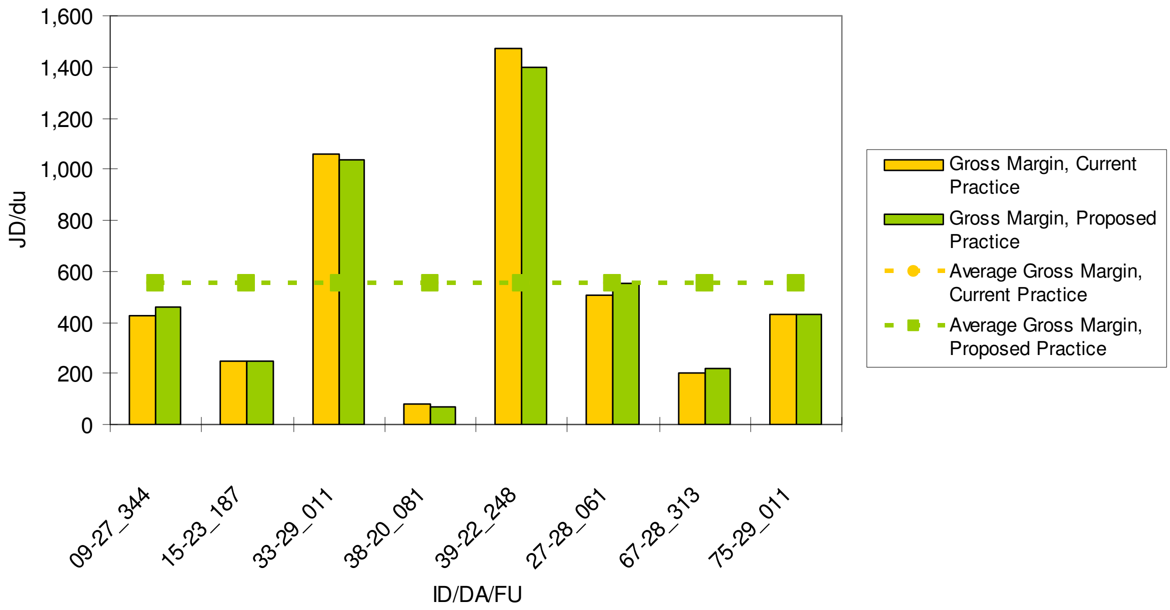

Figure 1 Tomato Open Field: Gross Margins

A number of conclusions may be drawn from the presented facts:

1. Crop management practices seem to differ to a large extent as shown by the large standard deviations in yield and variable cost.

2. A shift from "current practice" to "proposed practice" would not significantly influence the average gross margin (current practice: 553 JD/du; proposed practice: 552 JD/du).

3. Generally speaking, tomato production was profitable in the examined seasons – the net margin was negative in only one case where yield was less than 3 tons/du.

4.1.2 Plastic House

Table 14 shows that in general tomato yields are much higher in PH than in OF production although, once again, the standard deviation is high enough to be cautious in this regard.

Table 14 Tomato Plastic House: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Variable Cost Proposed Practice
		kg/du	JD/du	JD/du	JD/du
05-26_004	Galia	17,728	2,370	1,542	1,226
19-29_216	Hybrid 795	24,160	3,229	1,610	1,514
23-22_251	Hana	17,600	2,353	1,218	1,208
24-22_248	Hana	14,695	1,964	1,119	1,075
29-24_010	Hana	16,320	2,181	1,450	1,160
52-26_004	Cecilia	18,144	2,425	1,582	1,244
62-22_247	Dahes	11,578	1,548	968	958
70-24_010	Hana	14,880	1,989	1,216	1,065
74-22_248	Ghaneema	6,612	884	743	722
77-22_251	Ghalia	15,200	2,032	1,150	1,113
84-24_028	Cecilia	10,224	1,367	1,061	916
85-24_028	Cecilia	9,657	1,291	1,018	872
	Average	14,733	1,969	1,223	1,089
	Std. Dev.	4,318	577	249	190

On the other hand, it can be seen that variable cost in PH production is almost three times as high as in OF production. This is mostly due to higher packaging and transportation cost as an effect of the largely increased average yield level. Higher pesticide and labour cost also have their share in increased variable cost as compared to OF production, yet to a lesser extent.

Figure 2 hereafter seems to indicate that most of the FUs realise gross margins well in the average range, yet the existing deviations make for the assumption that there is still leeway for improvement in a general sense.

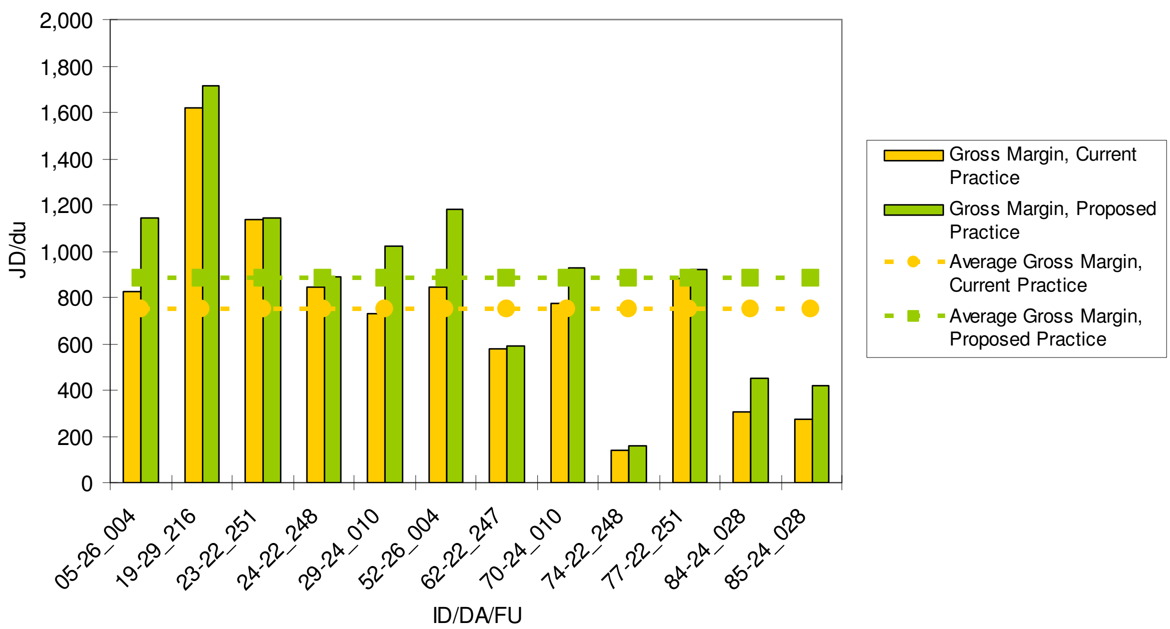

Figure 2 Tomato Plastic House: Gross Margins

As Table 15 shows there are several FUs on which fixed cost is higher than the – generally positive – gross margin. Therefore, production in these cases is not profitable although at a first glance the farmer's net return (sales value) is higher than his (variable) production cost.

This fact shows that the often neglected fixed cost plays an important role, particularly in PH production where it is 662 JD/du compared to 112 JD/du in OF production.

Table 15 Tomato Plastic House; Gross and Net Margins

		Gross Margin		Net Margin	
ID/DA/FU	Variety	Current Practice	Proposed Practice	Current Practice	Proposed Practice
		JD/du	JD/du	JD/du	JD/du
05-26_004	Galia	828	1,144	192	508
19-29_216	Hybrid 795	1,619	1,716	983	1,080
23-22_251	Hana	1,134	1,145	459	469
24-22_248	Hana	846	889	170	214
29-24_010	Hana	732	1,022	96	386
52-26_004	Cecilia	843	1,181	207	545
62-22_247	Dahes	580	590	-96	-85
70-24_010	Hana	773	924	97	249
74-22_248	Ghaneema	141	162	-534	-514
77-22_251	Ghalia	882	919	207	244
84-24_028	Cecilia	305	450	-370	-225
85-24_028	Cecilia	273	419	-403	-256
	Average	746	880	84	218
	Std. Dev.	369.1	387.3	377.9	399.5

The following conclusions can be drawn:

1. There seems to be less difference between FUs in terms of crop management practices than in OF production, as the standard deviations for yield and variable cost are lower.

2. In most cases, the shift from current practice to proposed practice increases gross margins and is therefore beneficial in an economic sense, thus "generating" money to be spent on qualified analytical and extension services.

3. Profitability (net margin) of PH tomato production seems to be lower than on OF and even negative in a non-negligible number of cases. Even if the macro-economic effect (permanent labour and thus income generation) of PH production of tomatoes is higher than the one of OF production, this is mostly due to higher transportation and packaging cost per du.

4.2 Eggplant

Eggplant is also grown both in open fields and in plastic houses. As it was the case for tomato, the features of both cultivation practices are remarkably different.

4.2.1 Open Field

The average yield of OF eggplant (5.4 tons/du) and the respective standard deviation of about 2 tons/du show that there may be at least a potential to stabilise production in the RWP area.

Table 16 Eggplant Open Field: Characteristics

				Variable Cost	
ID/DA/FU	Variety	Yield	Production Value	Current Practice	Proposed Practice
Unit		kg/du	JD/du	JD/du	JD/du
47-27_276	Classic	6,149	875	426	386
54-27_265	Classic	8,127	1,157	498	471
56-27_344	Classic	4,603	655	364	338
59-28_061	Classic	2,708	385	309	287

Average	5,397	768	399	371
Std. Dev.	1,992	284	71	68

Figure 3 presents gross margins for current and proposed practice. Both parameters are below the average for two FUs hinting at a potential for an increase there.

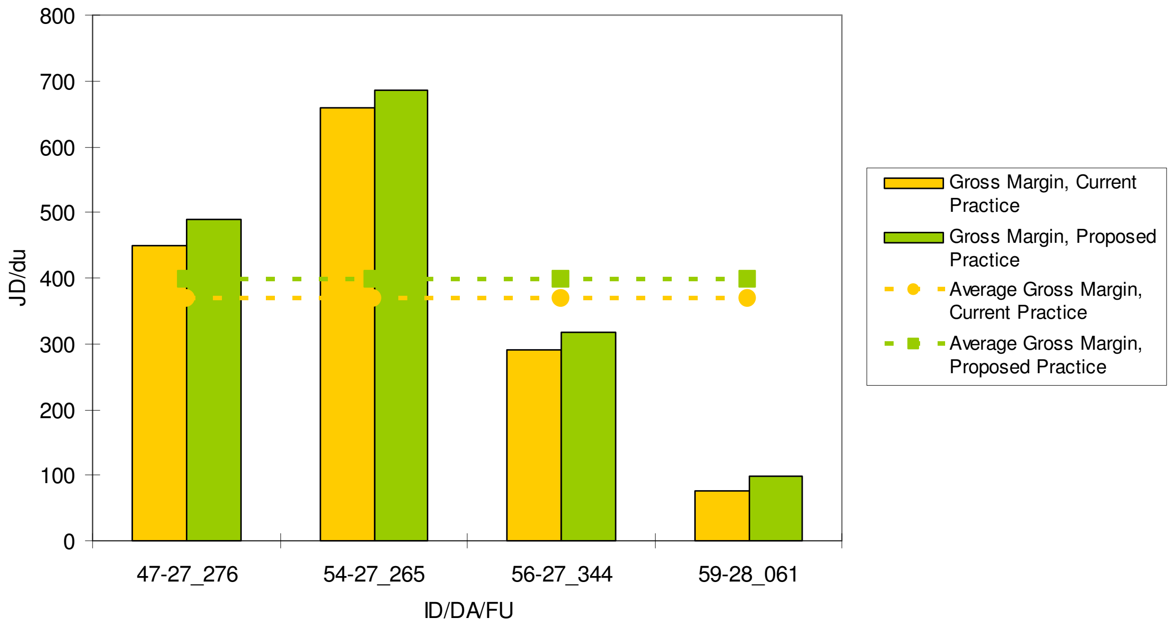

Figure 3 Eggplant Open Field: Gross Margins

Table 17 hereafter is characterised by two remarkable facts which are both due to respective yield levels: a production value of over 1,000 JD/du in one case, translating into highest gross and net margin values within the present sample, and a production value of less than 400 JD/du, leading to a meagre gross margin and a net margin which is even below zero with current practice (farmer makes a loss in eggplant production in the examined season).

Table 17 Eggplant Open Field: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin		Net Margin	
		Current Practice	Proposed Practice	Current Practice	Proposed Practice
		JD/du	JD/du	JD/du	JD/du
47-27_276	Classic	449	489	352	391
54-27_265	Classic	659	686	561	588
56-27_344	Classic	292	317	194	220
59-28_061	Classic	77	98	-21	1
	Average	369	398	272	300
	Std. Dev.	213	216	213	216

It can be concluded that

1. Crop management practices appear to have leeway for improvement so as to stabilise average yields.

2. “Proposed practice” in all cases results in improved economic performance as compared to “current practice”, which underlines the aforementioned conclusion.

4.2.2 Plastic House

Plastic house production of eggplant results in a higher average yield than OF production even if the recorded yields of three FUs may not be representative enough to talk of a significant difference compared to OF production.

Table 18 Eggplant Plastic House: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Variable Cost Proposed Practice
		kg/du	JD/du	JD/du	JD/du
07-27_276	Classic	10,120	1,440	1,018	891
25-22_248	Ajami	4,896	633	773	667
35-24_010	Dalia	10,920	1,412	1,046	920
	Average	8,645	1,162	946	826
	Std. Dev.	2,671	374	123	113

However, standard deviation of variable cost is lower than that of yield and production value, hinting at the possibility that yield on the second monitored FU was influenced by other factors outside the reach of the farmer, even if on this farm the input level as represented by variable cost appears to be much lower than on the other two FUs.

The fact that the second farm appears as an Ausreisser is also visible in Figure 4 below, where the negative gross margin is to be noted in compa[illegible]n to those of the other two FUs which are about in the same range.

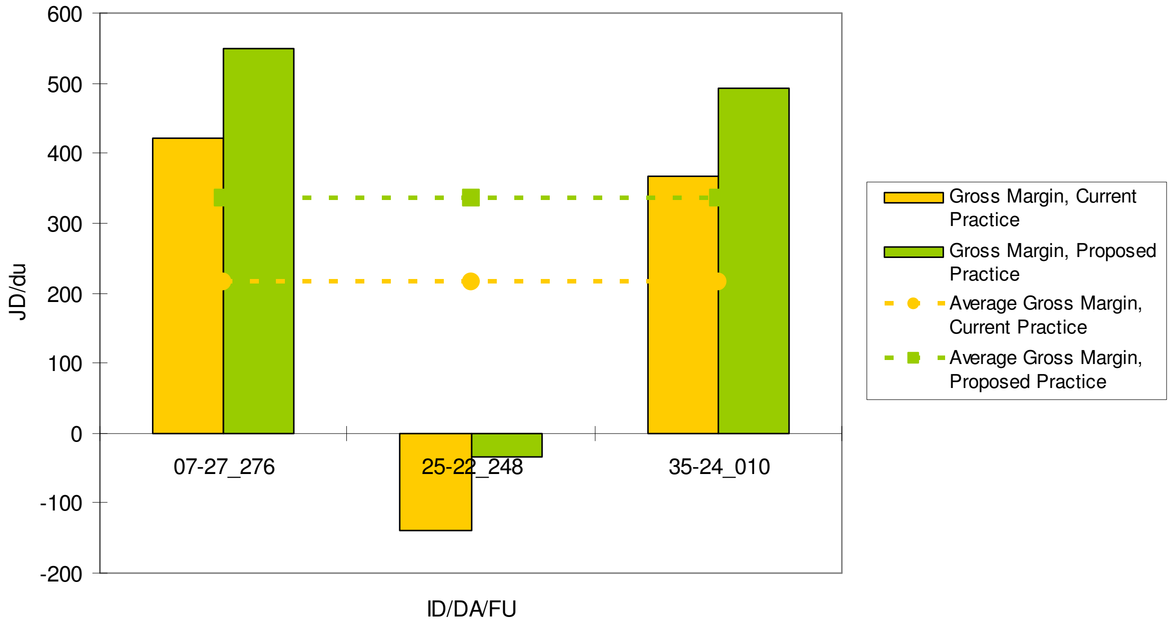

Figure 4 Eggplant Plastic House: Gross Margins

Figure 4 also clearly marks the difference between "current practice" and "proposed practice" averages, whereas Table 19 underlines this tendency

Table 19 Eggplant Plastic House: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	Gross Margin Proposed Practice	Net Margin Current Practice	Net Margin Proposed Practice
		JD/du	JD/du	JD/du	JD/du

07-27_276	Classic	422	549	-214	-87
25-22_248	Ajami	-139	-34	-815	-710
35-24_010	Dalia	366	492	-309	-183
	Average	216	336	-446	-326
	Std. Dev.	253	263	264	274

However, it also has to be noted that – at least in the seasons in question – eggplant cultivation did not appear to be profitable: in all cases (and even with "proposed practice") calculated net margins are below zero.

The following conclusions can be drawn:

1. Average yield levels in PH eggplant production are higher than in OF, yet average gross margins are lower due to product prices, a fact that shows the variety/quality influence on agricultural profitability.

2. Again, fixed cost is extremely important to consider: positive gross margins turn into negative net margins thus creating overall losses for farmers from PH eggplant production.

4.3 Sweet Pepper

Within the sample of monitored FUs, sweet pepper is cultivated only in open fields with an average yield of less than 1 ton/du. The large difference between best and worst performing FU in this context (1,630 kg/du and 540 kg/du, respectively) gives way to the assumption that either uncontrollable factors play their part or crop management practices are extremely heterogeneous with potential for improvement.

Table 20 Sweet Pepper Open Field: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	 Proposed Practice
		kg/du	JD/du	JD/du	JD/du
45-21_023	Sonar	690	178	240	221
49-22_247	Manal	890	229	250	216
65-20_081	Jupiter	1,630	420	273	249
46-22_248	Sonar	540	139	202	202
	Average	938	241	241	222
	Std. Dev.	419	108	26	17

As Table 20 shows, this translates in very low production values which are in about the same range as average variable cost.

As a matter of fact, the examined season was not a profitable one for sweet pepper cultivation. In three out of four examined cases "current practice" gross margins are negative with an overall average of zero JD/du (no money generated to cover any fixed cost).

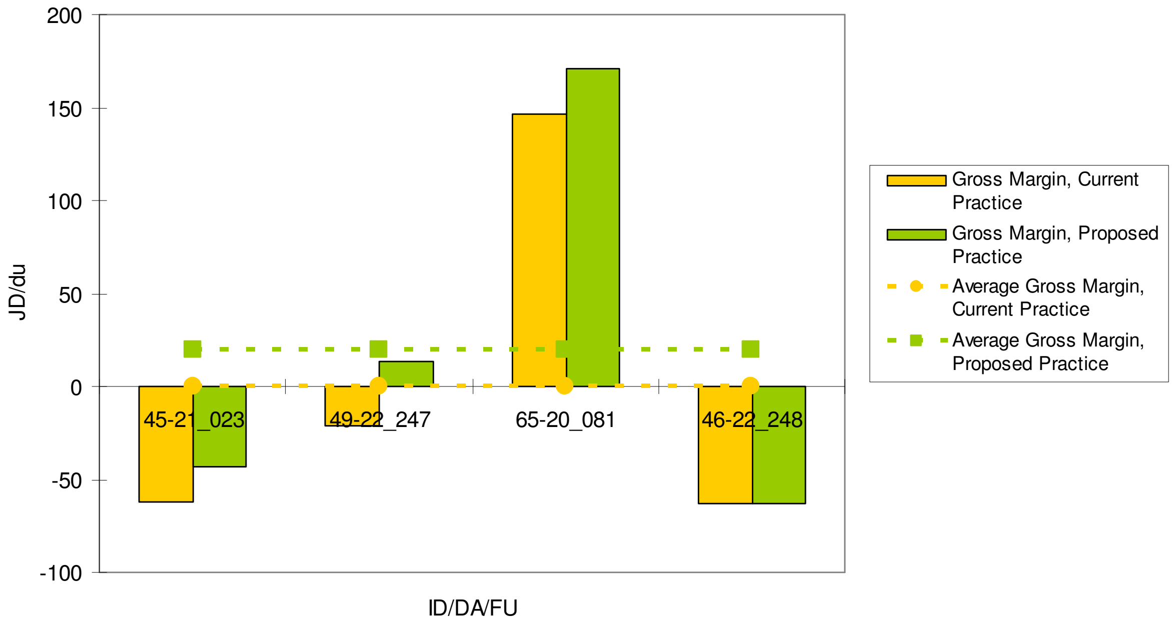

Figure 5 Sweet Pepper Open Field: Gross Margins

Figure 5 shows that even with "proposed practice" sweet pepper gross margins still remain negative on two FUs.

Table 21 shows that this time fixed cost is not at the origin of the discouragingly low net margins, which was expectable as production takes place in open fields; analysis of the present information shows that it is the extremely low yield level that is responsible for the bad performance.

Table 21 Sweet Pepper Open Field: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	Gross Margin Proposed Practice	Net Margin Current Practice	Net Margin Proposed Practice
		JD/du	JD/du	JD/du	JD/du
45-21_023	Sonar	-62	-43	-199	-180
49-22_247	Manal	-21	13	-158	-123
65-20_081	Jupiter	147	171	10	34
46-22_248	Sonar	-63	-63	-200	-200
	Average	0	20	-137	-117
	Std. Dev.	86	92	86	92

Conclusions of the presented information are as follows:

1. At least for the examined seasons, sweet pepper was a poor performer from the yield, gross margin and net margin points of view.

2. Shifting from "current practice to "proposed practice" improves the situation without having enough potential in general to turn profits (net margins) into positive.

4.4 Cucumber

Cucumber is only produced in plastic houses, with an average yield of 11.9 tons/du (standard deviation: 3.5 tons/du). As Table 22 shows, the general yield level is above 10 tons/du with two FUs having recorded less than 9 tons/du.

Table 22 Cucumber Plastic House: Characteristics

		Variable Cost

ID/DA/FU	Variety	Yield	Production Value	Current Practice	Proposed Practice
		kg/du	JD/du	JD/du	JD/du
26-26_004	189	17,168	3,597	1,530	1,213
30-24_010	189	8,526	1,786	1,072	854
31-22_251	Melin	7,980	1,672	887	833
53-26_004	189	17,008	3,563	1,624	1,241
63-24_033	Sadin	14,160	2,967	1,385	1,066
64-22_253	Melin	12,576	2,635	1,273	1,009
71-22_251	189	13,344	2,796	1,226	1,034
72-24_010	Melin	11,712	2,454	1,172	959
80-24_033	Sadin	13,720	2,874	1,259	1,055
81-22_253	Melin	12,320	2,581	1,227	1,005
87-23_444	189	10,784	2,259	1,066	980
	Average	11,924	2,498	1,205	993
	Std. Dev.	3,495	732	227	145

Variable cost is in more or less the same range for all FUs, indicating that there is not much difference between cropping practices on different FUs.

Figure 6 shows that gross margins in both “current practice” and “proposed practice” appear to be more stable than it is the case for some of the other examined crops (in particular, sweet pepper, tomato OF, eggplant PH, squash OF). This may hint at a generally increased level of know-how in cucumber production.

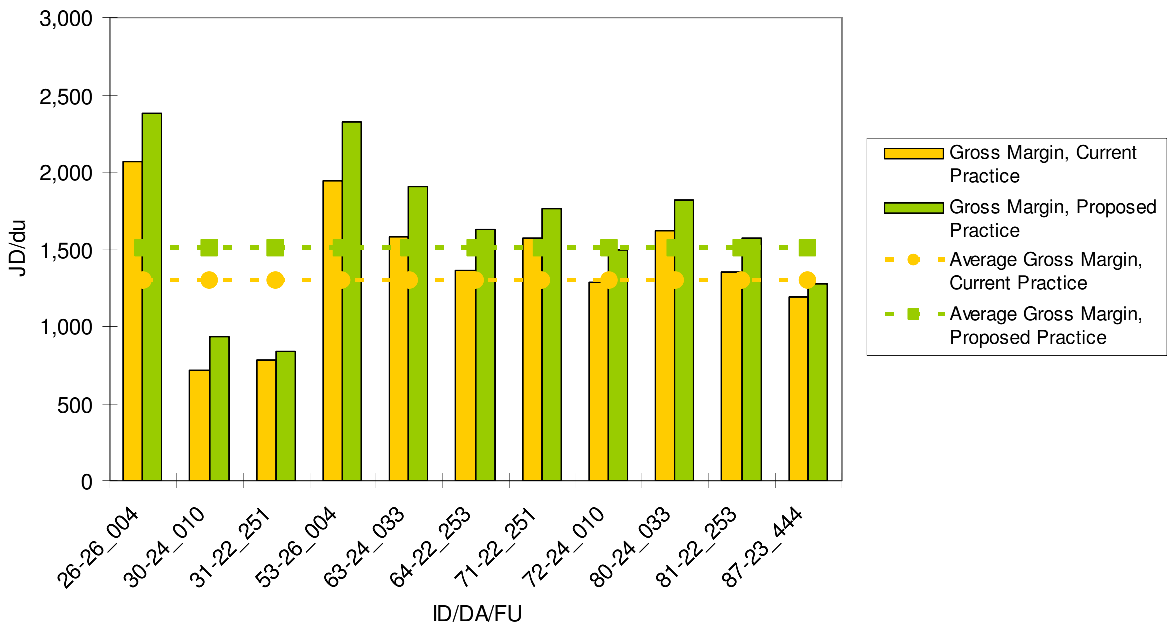

Figure 6 Cucumber Plastic House: Gross Margins

Table 23 Cucumber Plastic House: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	Gross Margin Proposed Practice	Net Margin Current Practice	Net Margin Proposed Practice
		JD/du	JD/du	JD/du	JD/du
26-26_004	189	2,067	2,383	1,431	1,747
30-24_010	189	715	932	39	256
31-22_251	Melin	784	839	109	163
53-26_004	189	1,939	2,322	1,303	1,686

63-24_033	Sadin	1,581	1,900	906	1,225
64-22_253	Melin	1,362	1,626	686	951
71-22_251	189	1,570	1,762	894	1,087
72-24_010	Melin	1,282	1,495	606	820
80-24_033	Sadin	1,615	1,820	940	1,144
81-22_253	Melin	1,354	1,576	679	901
87-23_444	189	1,193	1,280	518	604
	Average	1,293	1,505	627	839
	Std. Dev.	514.5	588.7	515.8	590.6

Table 23 once again points at the fact that fixed cost must not be neglected when assessing the economic performance of cultivation of a specific crop, especially in PH production. While gross margins are well above 1,000 JD in most cases, net margins suffer significantly from the high depreciation of fixed assets.

The conclusions that can be drawn from the information as presented above are the following:

1. PH production of cucumber is highly profitable in most cases, when compared to other crops.

2. Know-how may play an important part in smoothing out differences between FUs

3. A look at the performance of the same varieties used on different FUs allows for the supposition that there may be leeway for improving productivity in distinct cases.

4. The shift from “current practice” to “proposed practice” in all cases results in increased gross and net margins, thus making it potentially worthwhile to pay for appropriate and qualified extension services.

4.5 Squash

Squash is only produced on open fields with an average harvest of 2.3 tons/du. Variety may play a certain role in yield levels, yet the poor performance of varieties “Amira” and (to a lesser extent) “3 cycles” may as well be caused by external factors out of the farmer’s influence.

Table 24 Squash Open Field: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Proposed Practice
		kg/du	JD/du	JD/du	JD/du
36-24_010	Anita	4,088	872	287	291
40-27_344	Amira	408	87	151	181
58-28_061	3 cycles	1,416	302	218	214
76-24_010	Zodiac	3,220	687	327	249
	Average	2,283	487	246	234
	Std. Dev.	1,449	309	67	41

It is the two FUs that used the mentioned varieties during the examined season that had gross margins below zero, as Figure 7 below shows. It can also be noted that for the present sample tha average gross margins with “current practice” and “proposed practice” do not differ very much.

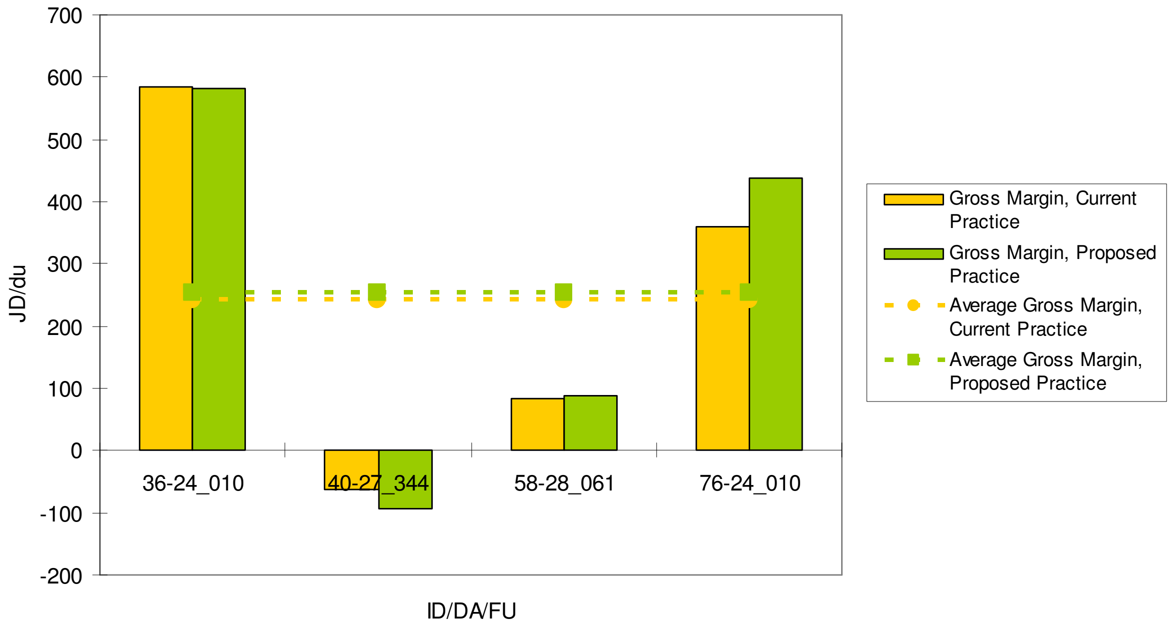

Figure 7 Squash Open Field: Gross Margins

As a matter of fact, gross margin is increased by a shift from "current practice" to "proposed practice" in only one case; in two cases, virtually no changes are calculated whereas in one case gross margin even decreases further. This is due to the fact that the agronomic recommendations imply higher fertiliser applications as current practice does not seem to cater for plant requirements. The two FUs where gross margins remain at the same level seem to irrigate and fertilise according to the actual requirements.

Table 25 Squash Open Field: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	Gross Margin Proposed Practice	Net Margin Current Practice	Net Margin Proposed Practice
		JD/du	JD/du	JD/du	JD/du
36-24_010	Anita	585	582	448	445
40-27_344	Amira	-64	-94	-161	-191
58-28_061	3 cycles	84	88	-14	-9
76-24_010	Zodiac	360	438	262	340
	Average	241	253	134	146
	Std. Dev.	250	269	237	257

Table 25 indicates that the data basis for squash is relatively weak, with standard deviations for gross and net margins in both "current" and "proposed practice" higher than the respective average values.

Conclusions to be drawn from the available squash data are:

1. Large deviations can be due to varietal or management factors, or may even be influenced by external factors; a larger data basis would be required.

2. As long as the varietal influence cannot be determined, it will be difficult to assess the impact of agronomic recommendations on crop profitability.

4.6 Okra

Open field cultivated Okra has an average marketable yield of 3.4 tons/du, yet the present sample covers only two FUs. Again, yield difference may be due to varietal factors at first glance, yet the limited number of FUs monitored would make such a conclusion sheer speculation.

Table 26 Okra Open Field: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Proposed Practice
		kg/du	JD/du	JD/du	JD/du
02-26_008	Posasawani	2,990	2,806	381	377
43-26_008	Climson /spinless	3,780	3,548	390	417
	Average	3,385	3,177	385	397
	Std. Dev.	395	371	4	20

Gross margins do not differ significantly in "current practice" and "proposed practice" as Figure 8 shows.

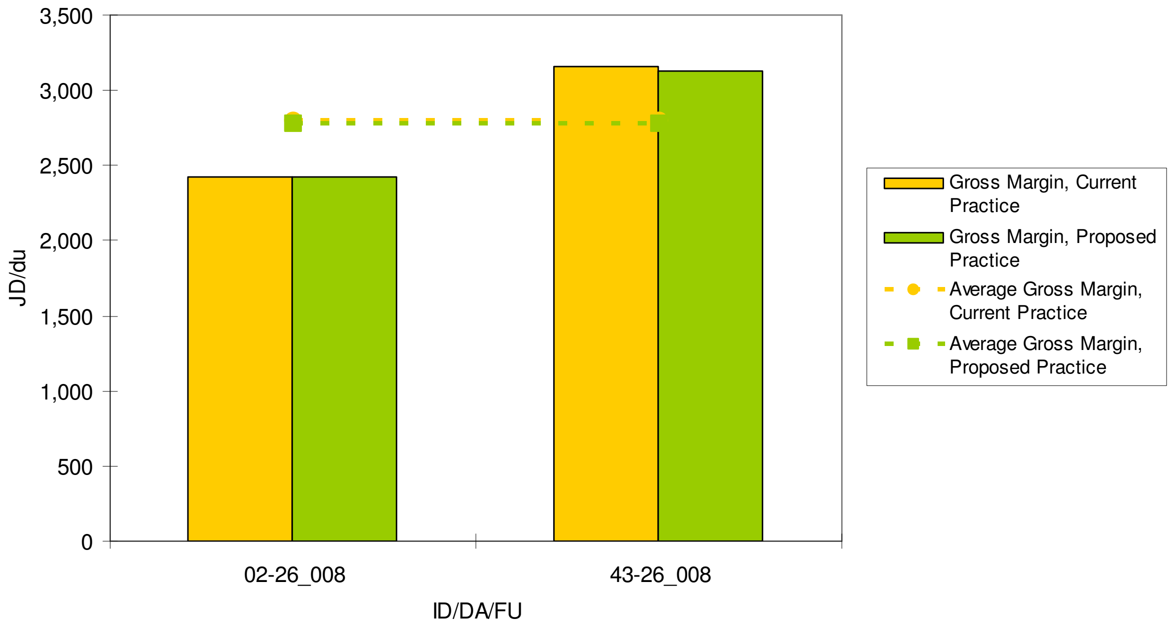

Figure 8 Okra Open Field: Gross Margins

When compared to the other crops in the present monitoring sample, it appears that Okra produces extremely advantageous gross and net margins, in particular when compared to other open field crops. However, the disadvantage of Okra is the required seasonal labour for harvest, which (i) is quite high and (b) comes at a moment when many foreign workers have left for their home countries. Although the cost for seasonal labour has been doubled in calculating gross margins as compared to other open field crops, labour availability may pose substantial problems.

Table 27 Okra Open Field: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	Proposed Practice	Net Margin Current Practice	Proposed Practice
		JD/du	JD/du	JD/du	JD/du
02-26_008	Posasawani	2,425	2,429	2,327	2,332

43-26_008	Climson /spinless	3,158	3,130	3,060	3,033
	Average	2,791	2,780	2,694	2,682
	Std. Dev.	367	350	367	350

Conclusions to be drawn are

1. The simple fact that gross margins are remarkably high does not in itself justify extended Okra cultivation. Market context and especially labour availability have to be taken into account.

2. The sample is not large enough to allow for qualified conclusions with regard to varietal or crop management influences.

4.7 Date Palm

In the Jordan Valley, date palms have an economic lifetime of about 25 years. Simplified yield development over this timespan is depicted in Table 28.

Table 28 Date Palm: Yield Development over 25 Years

Year	Yield (% full potential)
1	0
2-3	15
4-9	70
10-25	100

Yield can reach up to 3.4 tons/du. The present sample of two FUs which, however, are managed by the same farmer, currently has yields of about 2 tons/ha. Therefore, it can safely be assumed that productivity increases are still feasible.

Table 29 Date Palm Open Field: Characteristics

ID/DA/FU	Variety	Yield	Production Value	Variable Cost Current Practice	Variable Cost Proposed Practice
		kg/du	JD/du	JD/du	JD/du
13-25-131	Majdool	2,000	4,000	532	374
14-26-448	Majdool	2,000	4,000	494	374
	Average	2,000	4,000	513	374
	Std. Dev.	0	0	19	0

Difference in variable cost is low which certainly is due to the fact that the plantation owner in both cases is the same.

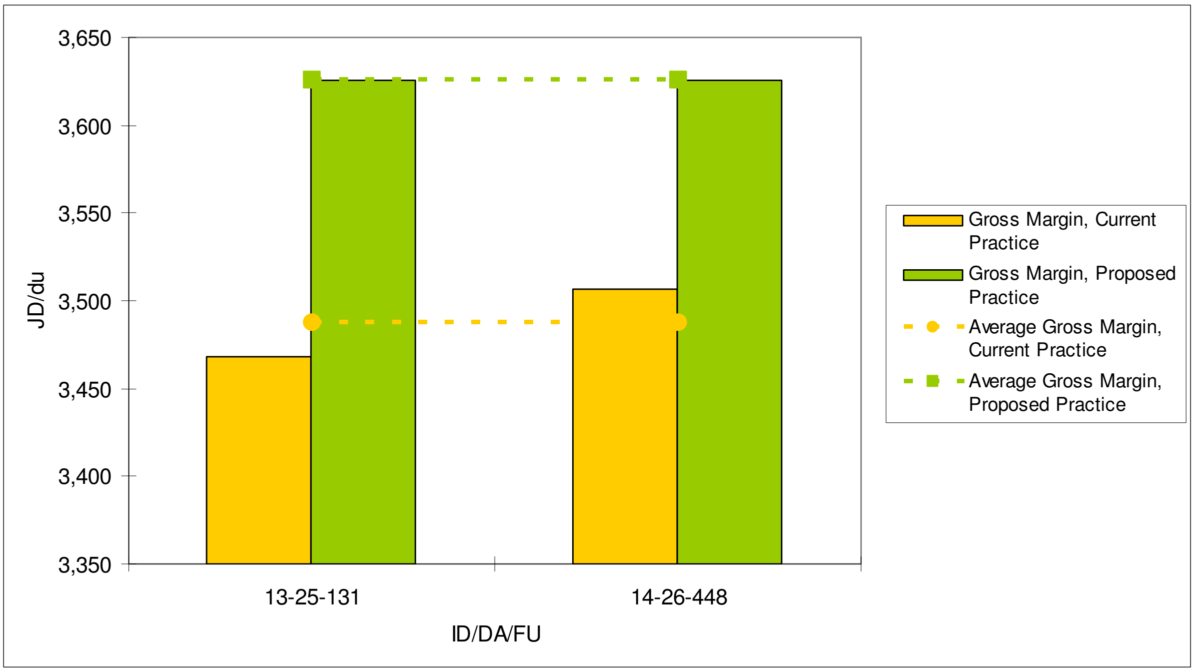

Figure 9 Date Palm Open Field: Gross Margins

In Figure 9 large differences between gross margins for "current practice" and "proposed practice" can be noticed. These are due to the fact that currently fertilisation and irrigation are practised in a much more intensive manner than would be recommendable from the agronomic point of view.

Table 30 Date Palm Open Field: Gross and Net Margins

ID/DA/FU	Variety	Gross Margin Current Practice	 Proposed Practice	Net Margin Current Practice	 Proposed Practice
		JD/du	JD/du	JD/du	JD/du
13-25-131	Majdool	3,466	3,626	3,166	3,324
14-26-448	Majdool	3,506	3,626	3,244	3,363
	Average	3,487	3,626	3,205	3,344
	Std. Dev.	19	0	39	20

The high gross margins are due to the fact that the whole harvest quantity was assumed to be exported; in this case the farmer would fetch a sales price of 2 JD/kg whereas the local price would be much lower.

It can be concluded that

1. Seemingly high input levels of chemical fertiliser and irrigation water unnecessarily harm the farmer's profit, at least in the season under scrutiny.

2. The data basis is too limited to allow for a detailed analysis of farming practices and their eventual economic repercussions.

3. In case produce quality is high enough, dates may be exported and may thus fetch high sales prices.

4.8 Overview of Gross and Net Margins

Table 31 is an overview of economic parameters of all assessed crops, comprising OF and PH production as well as "current" and "proposed practice".

Table 31 Overview of Variable and Fixed Cost, and Gross and Net Margins

Crop	Method	Production Value	Variable Cost		Gross Margin		Fixed Cost		Net Margin	
			Current Practice	Proposed Practice	Current Practice	Proposed Practice	Current Practice	Proposed Practice	Current Practice	Proposed Practice
		JD/du	JD/du	JD/du	JD/du	JD/du	JD/du	JD/du	JD/du	JD/du
Cucumber	PH	2,498	1,206	993	1,293	1,505	**666**	**666**	627	839
Tomato	PH	1,969	**1,223**	**1,089**	746	880	662	662	84	218
Tomato	OF	1,027	473	474	553	552	112	112	441	440
Tomato	Ø PH/OF	1,498	848.1	782	650	716	387	387	263	329
Eggplant	PH	1,162	946	826	216	336	662	662	-446	-326
Eggplant	OF	768	399	371	369	398	98	98	272	300
Eggplant	Ø PH/OF	965	672	598	293	367	380	380	-87	-13
Datepalm	OF	**4,000**	513	374	**3,487**	**3,626**	282	282	**3,205**	**3,344**
Okra	OF	3,176	385	397	2,791	2,780	98	98	2,694	2,682
Squash	OF	487	246	234	241	253	107	107	134	146
S. Pepper	OF	241	241	222	0	20	137	137	-137	-117

This table shows that date production brings about the highest sales value. Together with a median variable cost, gross margin is also highest in date palm cultivation. As fixed cost is also not too high, despite plantation cost and a land rent at the higher of the two recorded levels, date production is also the most profitable from the net margin point of view.

For all three parameters, okra comes in second, already with remarkable distances. Cucumber production takes the third place although it has the second highest variable cost and the highest fixed cost in the whole assessed sample.

The difference between fixed cost for PH and OF production gives way to the conclusion that fixed cost in any case must not be neglected when considering overall profitability of a crop.

Eggplant PH and sweet pepper production figure least profitable, at least in the examined seasons. It would seem that, for the former, OF production is much more profitable, while production of sweet pepper can only be seen as part of diversification strategy of farmers, or to fill in gaps in the cultivation calendar. However, year-on-year comparison may reveal a different picture.

5 Productivity Indicators

Although the calculated productivity indicators (average yield/m³ irrigation water; average yield/kg N applied) may seem to be of more interest in agronomic terms, they can be helpful in analysing time series for a given crop – or in comparing "current practice" and "proposed practice".

5.1 Irrigation Water

Figure 10 below shows mean irrigation water productivities for all assessed crops; it has to be noted, however, that this is done for simplicity reasons: physical productivities of different crops must not be compared with each other.

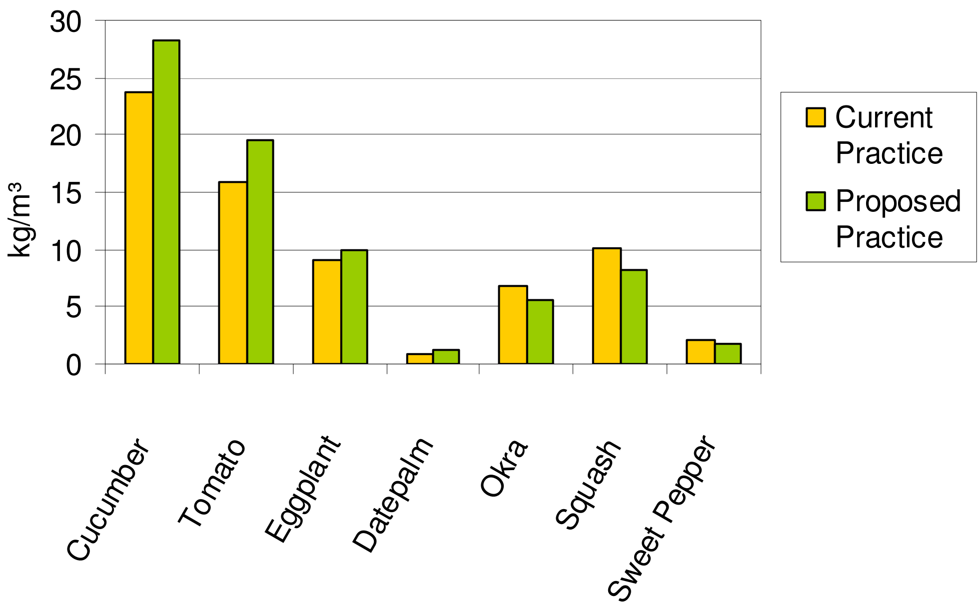

Figure 10 Irrigation Water Productivities

What can be seen in this figure is that in four cases (cucumber, tomato, eggplant and date palm) the shift from "current" to "proposed practice" increases irrigation water productivity; the indicator worsens for okra, squash and sweet pepper. This is due to increased irrigation recommendations as elaborated in the RW Guidelines which do not go hand in hand with increased yield expectations.

5.2 Fertiliser

The picture is somewhat different with regard to the productivity of nitrogen (total N from all sources, i.e. water, manure, chemical fertiliser).

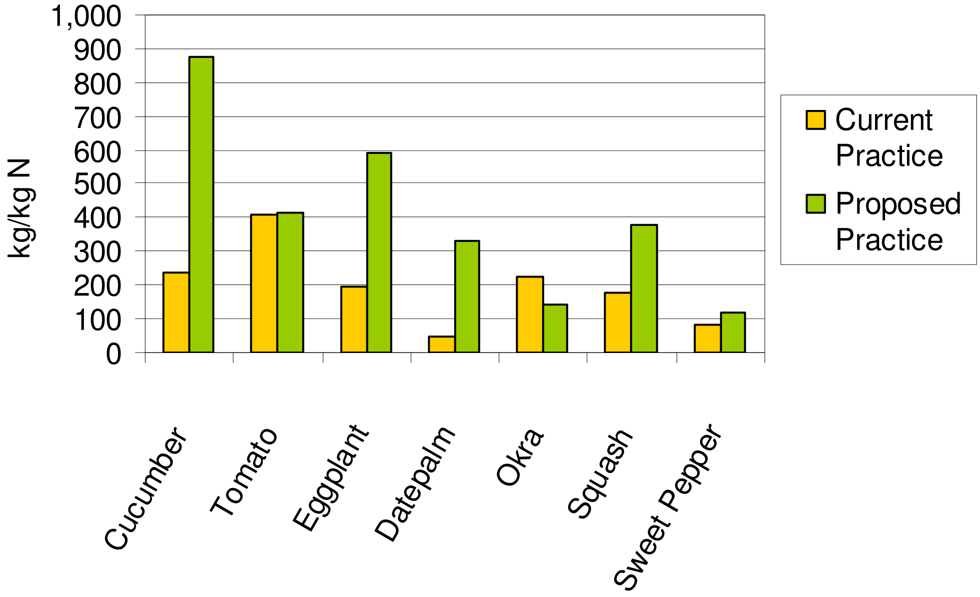

Figure 11 Nitrogen Productivities

Figure 11 depicts rather large changes in nitrogen productivity for cucumber, eggplant, date palm and squash; this is a sign of excess fertilisation in "current practice". The difference is negligible for tomato and sweet pepper, whereas okra could use more nitrogen than is currently applied.

It might be interesting to follow up with some of the FUs where large productivity leaps are predicted from information in the RW Guidelines so as to see whether yield levels suffer from current fertilisation amounts.

6 Profitability Indicators

In contrast to what was said above for the productivity indicators, the calculated profitability indicators (output per m³ irrigation water and per kg N from chemical fertiliser, with output being defined as gross margin plus cost for the respective input) of different crops may well be compared with each other.

6.1 Irrigation Water

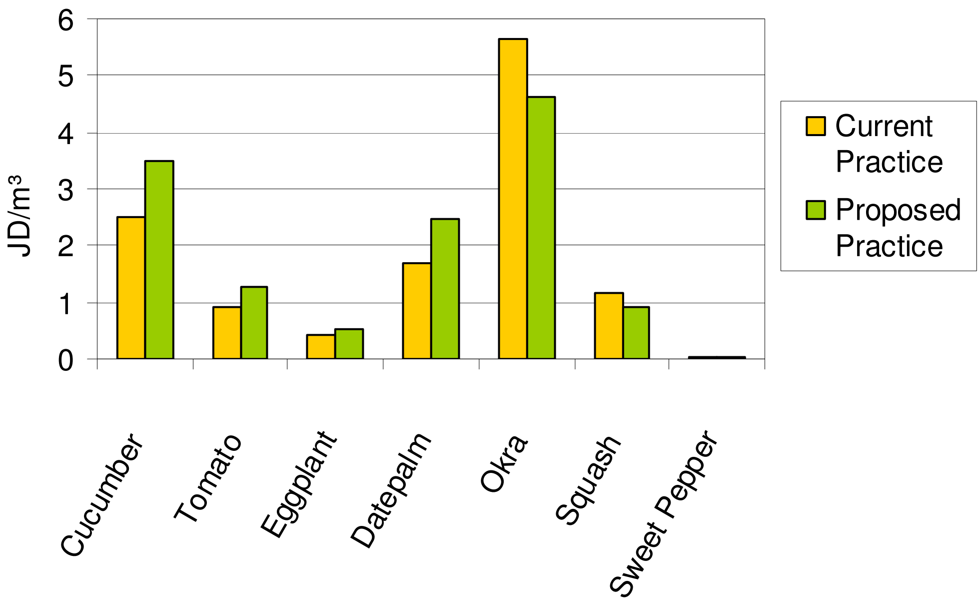

Figure 12 Irrigation Water Profitabilities

Water profitability increases are feasible when shifting from "current" to "proposed practice" in cucumber, tomato, eggplant, date palm and even sweet pepper. The value decreases for okra and squash, a result of increased irrigation recommendations.

Table 32 Irrigation Water Profitabilities: Proposed Practice

Crop	Method	Irrigation amount	Output per m³ irrigation water
		m³/du	JD/m³
Cucumber	Plastic House	587	3.505
Tomato	Average PH/OF	905	1.269
Eggplant	Average PH/OF	905	0.529
Datepalm	Open Field	2,167	2.375
Okra	Open Field	517	**4.618**
Squash	Open Field	589	0.913
Sweet Pepper	Open Field	602	0.042

Table 32 contains information about the relative preferability of the examined crops with regard to the use that they make of irrigation water. It appears that okra and cucumber are by far the crops with the highest irrigation profitability (4.6 JD/m³ and 3.5 JD/m³, respectively, at current irrigation levels). They are followed by date palm and tomato with values well above 1 JD/m³. Profitability for squash and eggplant drops below this value and sweet pepper figures last with an output of only 42 Fils/m³.

It can be deduced that all crops make profit out of water. However, at least during the two seasons ~~during which FUs were monitored,~~ there are significant differences that justify the assumption that some crops make better use of water (from the macro-economic perspective) than others.

Furthermore, the values given in the table are interesting in the way that they represent kind of threshold prices for water: As an example, the 4.618 JD/m³ for okra imply that at this very price of water, okra production would stop being profitable. Up to such a price, all variable cost is covered by the gross revenue of the crop, which in economic terms is a short term requirement for any enterprise. In the long run, such a price would mean that farmers would not be able to cover fixed cost (thus in some cases to pay interest on loans), they would drift towards bankruptcy.

In other words, any price for irrigation water below 4.618 JD/m³ would leave the farmer with positive gross margin in his okra production, however small this would be. If this irrigation water price were higher than 3.505 JD/m³, none of the other crops would generate a positive gross margin.

With cropping area percentages as weighting factor, and related profitability indicators for all crops cultivated in the Jordan Valley, it would become possible to calculate an average irrigation water cost that could serve as a (more theoretical) threshold for water pricing. Such a value would have to be recalculated each year as seasonal fluctuations may influence the whole picture.

Time series of data would be desirable to see whether the crops which appear to be favourable in the context of the present assessment show a similar level of preferability over a longer period.

6.2 N-Fertiliser

Nitrogen profitability was only calculated for N from chemical fertiliser because

- not all fields receive manure as an N-source; and
- N in irrigation water is more of a side product with a limited influence (water applications are not determined with regard to N-content)

In the cases of tomato, eggplant and okra, profitability of N from chemical fertiliser decreases with a shift from “current” to “proposed practice” which is due to recommended higher N-fertilisation levels in the RW guidelines. Date palm in particular, but also cucumber and to a lesser extent squash see their N profitabilities increased; again, this hints at current excess fertilisation.

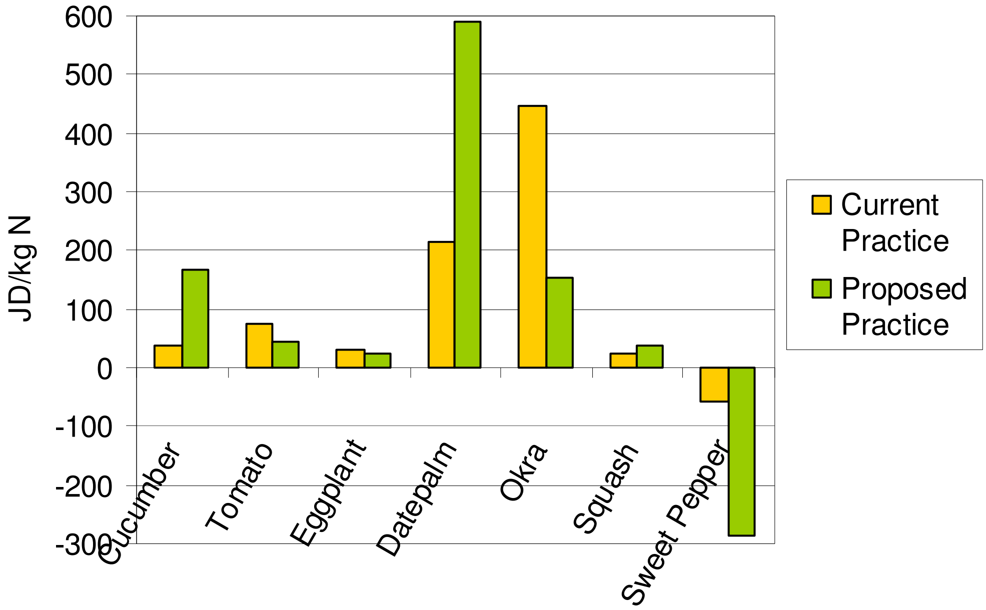

Figure 13 **Profitabilities of N from Chemical Fertiliser**

Due to the low sales value of sweet pepper in the examined timespan, this crop has a negative N profitability in both practices.

In general terms, two facts have to be kept in mind:

1. Profitabilities as presented above for both irrigation water and N from chemical fertiliser do not represent a steady state; as fertiliser and irrigation recommendations may vary over time, the related profitabilities may also fluctuate.

2. The data basis is relatively weak, in particular with respect to okra, and date palm, as in both cases only two FUs have been monitored. On such grounds any recommendation or conclusion must be placed under great caution.

7 Irrigation Water Use Efficiency

As an indicator for the added value of one m³ of irrigation water (in terms of JD net margin), irrigation water use efficiency is of virtually no interest to farmers; yet on the decision-making level, the indicator may be used to compare (i) different crops, and (ii) on an aggregate basis, different productive sectors of an economy.

Irrigation water use efficiency for the crops and FUs in the RWP databank is presented in Figure 14 below.

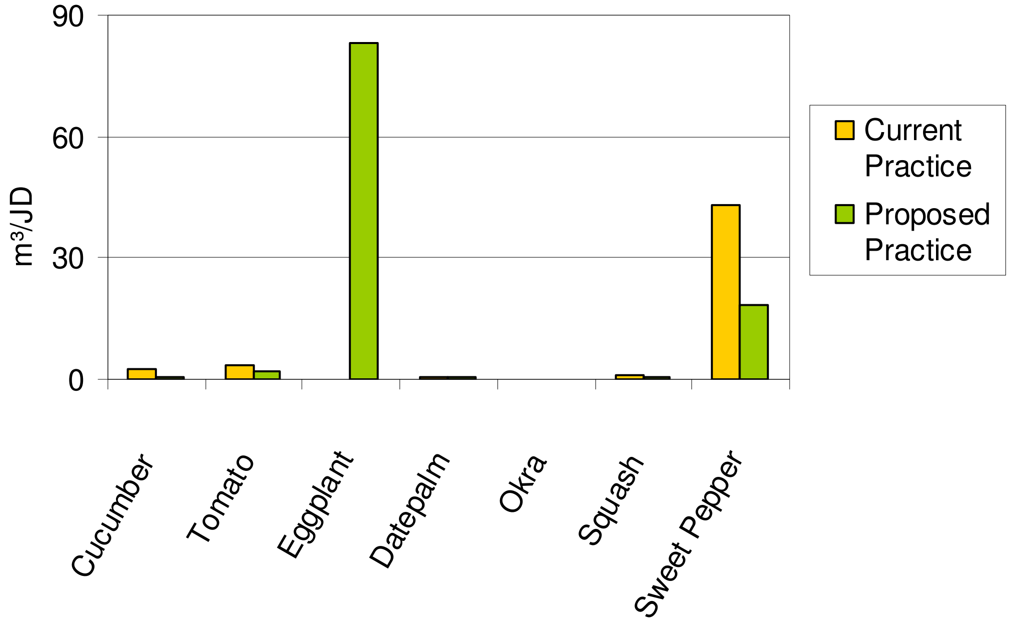

Figure 14 Irrigation Water Use Efficiencies

Eggplant and sweet pepper show extremely high values when compared to the other crops; a reason for this may be the limited availability of dat herefore, Table 33 shows the values of this indicator for all other examined crops.

Table 33 Selected Irrigation Water Use Efficiencies

Crop	Current Practice	Proposed Practice
	m³/JD	m³/JD
Cucumber	2.56	0.65
Tomato	3.70	1.81
Date palm	0.68	0.46
Okra	**0.19**	**0.24**
Squash	0.79	0.73

The above table shows that in almost all cases, the shift from “current” to “proposed practice” leads to improved irrigation water use efficiency (less water required for 1 JD net margin). Only in the case of okra a small increase can be noted.

However, in both practices it is okra that appears to generate the highest added value out of irrigation water, followed in “proposed practice” by date palm, cucumber and squash. Tomato figures last (as in “current practice”) with a large difference to the next best crop squash.

8 Comparison of Plastic House and Open Field Production

Within the RWP databank, information on tomato and eggplant production covers both open field and plastic house production. The following is a comparison of both production types, distinguished by crop. For simplicity reasons, only the “proposed practice” is presented hereafter.

8.1 Tomato

A comparison of indicators for tomato plastic house and open field production is presented in Table 34 below.

Table 34 Tomato PH and OF Production: Comparison of Indicators

Method	Yield	Production value	Gross margin	Net margin	Water productivity	Nitrogen productivity	Water profitability	Nitrogen profitability	Irrigation water use efficiency
	kg/du	JD/du	JD/du	JD/du	kg/m³	kg/kg N	JD/m³	JD/kg N	m³/JD
Plastic House	14,733	1,969	880	218	24	397	1.5	31.0	1.7
Open Field	7,680	1,027	552	440	15	436	1.0	54.7	1.9
Average PH/OF	11,206	1,498	716	329	20	417	1.3	42.9	1.8
Favorable Method	PH	PH	PH	OF	PH	OF	PH	OF	PH

This comparison shows that the values of six of the assessed indicators are better in plastic house production, among them all those that are important for the farmer and those which reflect the (macro-economic) value of water. Plastic house production therefore appears to be the preferable type of tomato production.

8.2 Eggplant

The indicators as calculated for eggplant PH and OF production are presented in Table 35 below.

Table 35 Eggplant PH and OF Production: Comparison of Indicators

Method	Yield	Production Value	Gross Margin	Net Margin	Water productivity	Nitrogen productivity	Water profitability	Nitrogen profitability	Proposed Practice
	kg/du	JD/du	JD/du	JD/du	kg/m³	kg/kg N	JD/m³	JD/kg N	m³/JD
Plastic House	8,645	1,162	336	-326	13	365	0.5	24.1	n.a.
Open Field	5,397	768	398	300	7	821	0.5	25.8	165.8
Average PH/OF	7,021	965	367	-13	10	593	0.5	24.9	82.9
Favorable Method	PH	PH	OF	OF	PH	OF	OF	OF	PH

While yield and production value are higher in PH production, gross and net margin clearly show that from the farmer’s perspective OF production should be preferred. Due to high fixed cost in PH production, net margin here is even negative. Both production types achieve the same water profitability of 0.5 JD/m³ while the water requirement per JD added value cannot be calculated (PH) or is extremely high (OF) when compared to other crops.

All in all, open field production seems to be the favourable production method, yet this can only be said under the restriction that the available data basis is relatively weak and that short term effects may disturb the picture; under long-term aspects and with increased data availability, preferability may shift from OF to PH production.

9 Overall Preferability/Ranking of Crops

The information and calculations as presented in the preceding chapters have been computed into a ranking of crops; however this ranking ~~was~~ only based on indicators representing a monetary component. Unweighted ranks are presented in the table below.

Table 36 Unweighted Ranking of Crops

Indicator	Production Value	Gross Margin	Net Margin	Output per m³ irrigation water	Output per kg N from chemical fertiliser	Water use per JD net margin	Mean Value	**Overall Rank**
	Rank							
Cucumber	3	3	3	2	2	3	2.7	**3**
Tomato	4	4	4	4	4	5	4.2	**4**
Eggplant	5	5	6	6	6	7	5.8	**6**
Datepalm	1	1	1	3	1	2	1.5	**1**
Okra	2	2	2	1	3	1	1.8	**2**
Squash	6	6	5	5	5	4	5.2	**5**
Sweet Pepper	7	7	7	7	7	6	6.8	**7**

As the importance of a given indicator may vary from one information user to another (e.g., farmers may attribute a different importance to certain indicators than decision makers) such a ranking cannot in any case be done objectively.

Therefore, two weighting systems have been applied so as to show that different objectives in an analysis of crop preferability may lead to different results. They represent two "scenarios", the first of which (A) emphasizes farmers' interests while the second one (B) is set up from a macro-economic perspective, putting more weight on water profitability and water use efficiency.

Both weighting systems are depicted in the following table.

Table 37 Weighting Factors for Determination of Crop Preferability

Indicator	Production Value	Gross Margin	Net Margin	Output per m³ irrigation water	Output per kg N from chemical fertiliser	Water use per JD net margin
Weighting factor (scenario A)	0.25	1	1	0.5	0.5	0.25
Weighting factor (scenario B)	0.25	0.25	0.25	1	0.5	1

An unweighted mean value was calculated (see Table 36 above) which was then taken as a basis for overall ranking. The results of the three different rankings (unweighted, scenario A, scenario B) are displayed in the following table.

Table 38 Crop Rankings (Unweighted and Weighted)

Crop	Unweighted rank	Weighted rank scenario A	Weighted rank scenario B
Cucumber	3	3	3
Tomato	4	4	4
Eggplant	6	6	6
Datepalm	1	1	2
Okra	2	2	1
Squash	5	5	5
Sweet Pepper	7	7	7

It can be seen that, based on the available information in the RWP databank and with the chosen weighting factors, the only changes from one scenario to another – and even to the unweighted ranking – occur on the first two places.

While in unweighted ranking and with emphasis on farmers' interests date palm seems to be the preferable choice just ahead of okra, a more water use-oriented weighting ranks okra first in front of date palm.

In any of the three cases cucumber takes the third place ahead of tomato, while sweet pepper figures last behind eggplant (sixth) and squash (fifth).

These results show the overall stability of the ranking. As a general conclusion, yet again under the restriction that the data basis is relatively weak and therefore caution should rule, it can thus be said that okra and date palm production should be extended, at the expense of sweet pepper, squash and eggplant.

10 Impact of Changing Water Prices

Irrigation water prices are a topic of heated debate in Jordan. While common understanding is that current irrigation water prices (15 Fils/m^3 on average) are too low to cover O&M costs of JVA's irrigation system (in 2005, the O&M cost was estimated at 28 Fils/m^3 [3]), the political willingness to address the issue and to raise irrigation water prices is not very strong.

Table 39 shows how the different calculated indicators would react to changing water prices. As basis for the related calculations, the following water prices were assumed:

- 30 Fils/m^3 (100% increase; price would cover O&M cost)
- 0.4 JD/m^3 (current price for drinking water in Amman)
- 0.568 JD/m^3 (water production cost for Disi-Amman conveyor[4])

Table 39 Overview of Gross and Net Margins with Different Water Prices

	Water Profitability (JD/m^3)	Gross Margin (JD/du)				Net Margin (JD/du)			
Water Price		**0.015 JD/m^3**	**0.030 JD/m^3**	**0.400 JD/m^3**	**0.568 JD/m^3**	**0.015 JD/m^3**	**0.030 JD/m^3**	**0.400 JD/m^3**	**0.568 JD/m^3**
Cucumber	3.505	1,505	1,499 -0.4%	1,346 -10.6%	1,277 -15.2%	839	833 -0.7%	680 -18.9%	611 -27.2%
Tomato	1.269	716	707 -1.2%	493 -31.1%	396 -44.7%	329	320 -2.6%	106 -67.8%	9 -97.3%
Eggplant	0.529	367	356 -2.9%	95 -74.0%	-23 -106.4%	-13	-24 n.a.	-285 n.a.	-403 n.a.
Datepalm	2.375	3,626	3,603 -0.6%	3,034 -16.3%	2,776 -23.4%	3,344	3,321 -0.7%	2,752 -17.7%	2,494 -25.4%
Okra	4.618	2,780	2,770 -0.3%	2,541 -8.6%	2,437 -12.3%	2,682	2,673 -0.3%	2,443 -8.9%	2,339 -12.8%
Squash	0.913	253	249 -1.7%	144 -43.0%	97 -61.8%	146	142 -2.9%	37 -74.7%	-11 -107.2%
Sweet Pepper	0.042	20	11 -42.1%	-192 -1080%	-284 -1551%	-117	-125 n.a.	-329 n.a.	-421 n.a.

The second column in Table 39 above displays the irrigation water profitability (output per m^3 irrigation water) which due to its formula is the same for all the assumed water prices. As it was said before, for each crop this value indicates the water price at which the specific gross margin is zero, i.e. at which cultivation of this crop becomes unprofitable.

An increase of the irrigation water price by 100% (to 30 Fils/m^3) would lead to gross margin decreases between 0.3% (okra) and 42% (sweet pepper). The effect with regard to net margins would be higher for a number of crops with decreases between again 0.3% for okra and 2.9% for squash. Sweet pepper and eggplant show negative net margins (real losses for the farmers) already at the current water price.

The more theoretical price levels of 0.4 JD/m^3 and 0.5698 JD/m^3 show that for most crops profits would be largely diminished. However, even with the highest assumed price, date

[3] source: KfW-financed feasibility study on reuse of TWW in irrigated agriculture in the Northern Jordan Valley

[4] Source: National Water Master Plan, 2004

palm and okra, and to a lesser extent cucumber, would still achieve gross and net margins high enough to carry on with these agricultural activities.

11 Economic Influence of Reclaimed Water

The economic influence of reclaimed water was assessed for single crops as well as on an aggregate level (RWP area). The results of this assessment are presented below.

As it was said in chapter 2.2.2 before, this assessment remains quite superficial as neither nutrient content nor irrigation water supply after rehabilitation of Khirbet As Samra WWTP could be estimated on a sound data basis. The figures below may well describe a tendency, yet it is not advisable to take them as representative for the future situation.

11.1 Current Situation

In the current situation, total value of N, P and K in irrigation water supply is about 2.34 million JD, out of which 23% are for N, 20% for P and 57% for K. Irrigation water taken from KAC-South contributes 40% of the total value, KTR water 60%.

Table 40 Nutrient Contents and Values in Irrigation Water– Current Situation

	KAC-South	KTR	Total
Irrigation water supply ("farm gate") (MCM)	37.21	42.25	79.45
$N\text{-}NO_3$ (mg/l)	5.86	6.08	
$N\text{-}NH_4$ (mg/l)	6.35	12.75	
$P\text{-}PO_4$ (mg/l)	2.28	3.25	
K (mg/l)	22.58	26.25	
Mean NH_4-volatization rate (%)	5.48	5.82	
Total effective N-content (kg)	298,204	534,664	832,868
N value (JD)	**192,080**	**344,389**	**536,470**
Total effective P-content (kg)	57,260	92,701	149,961
P value (JD)	**178,742**	**289,373**	**468,115**
Total effective K-content (kg)	567,159	748,546	1,315,705
K value (JD)	**576,297**	**760,607**	**1,336,905**
Overall nutrient value*	**947,119**	**1,394,370**	**2,341,489**

* only macro-nutrients N, P, K

11.2 After Rehabilitation/Extension of Khirbet As Samra WWTP

After rehabilitation of Khirbet As Samra WWTP, the total nutrient value of N, P and K will decrease by about 21% to then 1.85 million JD. N will account for 5% of this value, P for 27% and K for 67%. The relation between the values of water from KAC-South and KTR will remain stable.

A comparison of the information displayed in Table 40 and Table 41 reveals the following:

- N-contents will decrease the most, decrease of K-contents in irrigation water will be very moderate whereas P-content may increase slightly.
- Total effective N-content therefore decreases by more than 80% to about 152 tons per season of nine months (valued at about 98,000 JD).
- For total effective P-content over nine months, a slight increase from 150 tons to 163 tons can be noticed with a future value of 508,000 JD.
- Total effective K-content drops by 7% to 1,224 tons within nine months (value: 1.24 million JD).

Table 41 Nutrient Contents and Values in Irrigation Water– After Rehabilitation/Extension of Khirbet As Samra WWTP

	KAC-South	KTR	Total
Irrigation water supply (“farm gate”) (MCM)	37.21	42.25	79.45
$N\text{-}NO_3$ (mg/l)	1.33	1.85	
$N\text{-}NH_4$ (mg/l)	0.87	1.76	
$P\text{-}PO_4$ (mg/l)	2.48	3.53	
K (mg/l)	21.01	24.42	
Mean NH_4-volatization rate (%)	5.48	5.82	
Total effective N-content (kg)	52,837	99140	151,980
N value (JD)	**34,033**	**63.858**	**97,892**
Total effective P-content (kg)	62,172	100,652	162,824
P value (JD)	**194,073**	**413,194**	**508,268**
Total effective K-content (kg)	527,589	696322	1,223,912
K value (JD)	**536,091**	**707,542**	**1,243,632**
Overall nutrient value*	**764,197**	**1,085,595**	**1,849,792**

* only macro-nutrients N, P, K

11.3 Nutrient Value of Irrigation Water for Different Crops

The value of nutrients in irrigation water for different crops was assessed on the basis of applied irrigation rates (not effective irrigation), i.e. effective irrigation divided by the assumed irrigation efficiency of 90%. Nutrient values of irrigation water as presented in the RWP databank were divided by the respective irrigation amounts to obtain values per m³ (all for “proposed practice”).

The respective average irrigation amounts and nutrient values per m³ are given in the table below.

Table 42 Irrigation Amounts and Nutrient Values of Irrigation Water for Different Crops

Crop	Average irrigation amount	Average fertilisation value of irrigation water	
	m³/du	JD/du	JD/m³
Cucumber	587	10.959	0.019
Tomato	905	16.220	0.018
Eggplant	905	18.790	0.021
Datepalm	2,167	38.171	0.018
Okra	517	14.787	0.029
Squash	589	7.735	0.013
Sweet Pepper	602	9.018	0.015

12 Economic Influence of Brackish Water

The information collected and processed during the mission undertaken by the agro-economist allows comparing the agronomic and agro-economic effects of rising salinity for different crops cultivated in the Jordan Valley.

Table 43 overleaf presents EC_e and resulting EC_{iw} values with their respective yield, gross margin and net margin levels, expressed as percentage of maximum, for selected crops.

Two examples are presented in graphical form in Figure 15 for sweet pepper and Figure 16 for date palm.

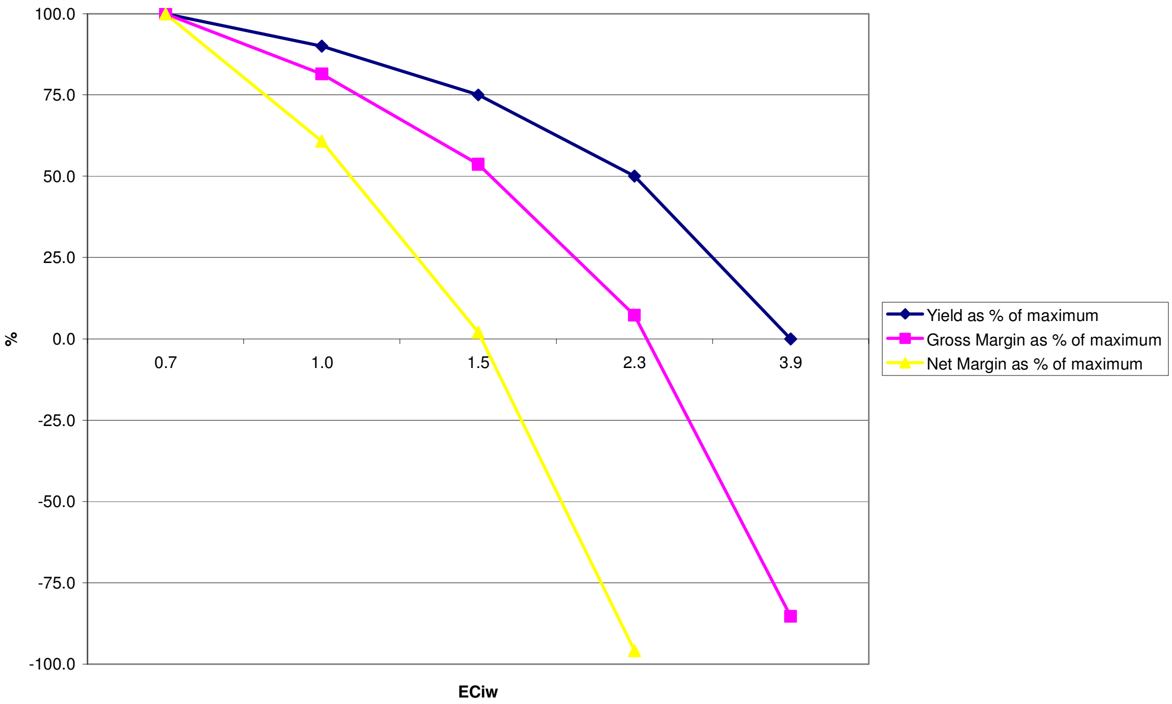

Figure 15 Sweet Pepper and Salinity: Agronomic and Agro-economic Effects

The threshold up to which sweet pepper may reach its full yield potential is quite low with an EC_e o[illegible]0 dS/m and a (calculatory) EC_{iw} of 0.7 dS/m. At an irrigation water salinity of 3.9 dS/m (EC_e = 5.8 dS/m), yield is reduced to zero.

However, Figure 15 clearly shows that this is a purely agronomic threshold: the gross margin reaches a level of zero JD/du at an irrigation water salinity of slightly above 2.3 while already at EC_{iw} = 1.5 dS/m, the net margin is close to zero; a little more salinity in the water would mean that yield is reduced to an extent that the farmer would lose money in sweet pepper production.

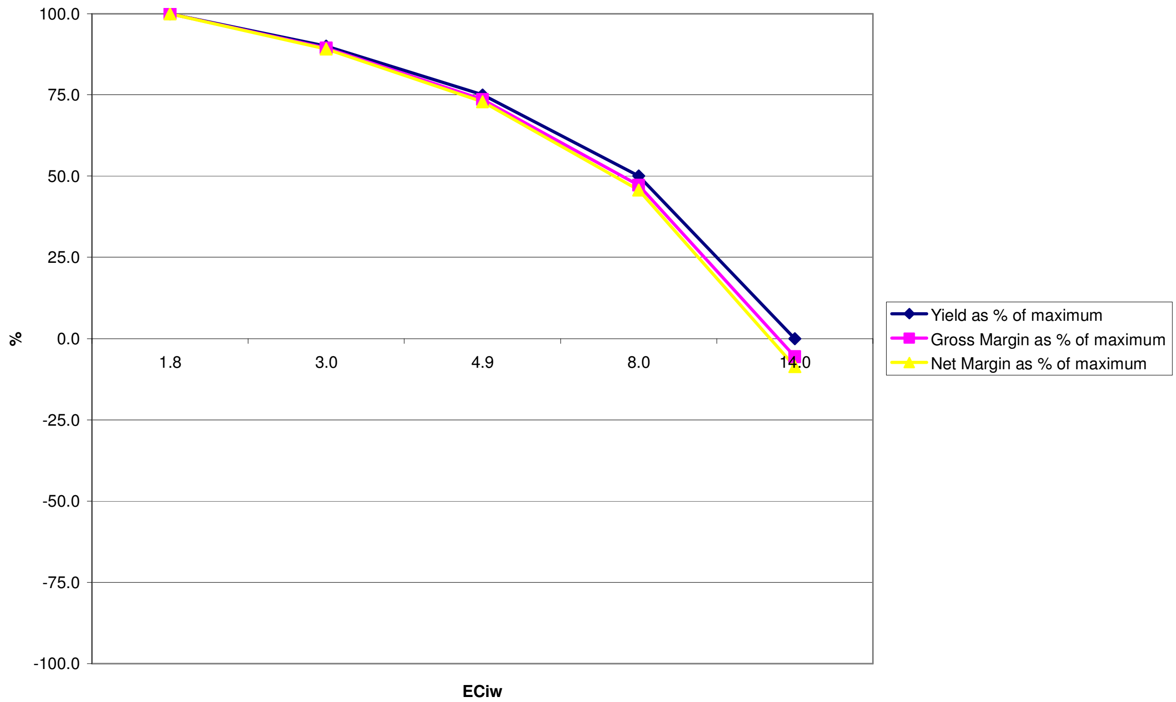

Figure 16 Date Palm and Salinity: Agronomic and Agro-economic Effects

Figure 16 in an impressive manner shows that date palm can tolerate saline water to a much larger extent than sweet pepper (as well as most of the other crops grown in the Jordan Valley; see also Annex C.)

In this case, agronomic and agro-economic effects are not as different as for other crops. Furthermore, the salinity at which from both points of view the production of dates is no longer feasible is relatively high (EC_{iw} of about 14 dS/m).

At ECiw = 8.0 dS/m, yield is at 50 % of the maximum that can be obtained while gross and net margin still reach 47% and 46% 0f the maximum, respectively. At such a salt content in irrigation water, yield levels of the other crops dealt with in the present report would be close to, or even already at 0%.

Two major conclusions can be drawn from the information and calculations presented in this chapter:

1. The agro-economic effect of increased salinity levels in irrigation water may be largely higher than the agronomic one. In most cases, long-term economic feasibility of the crop (positive net margin) is put at risk long before yields are reduced to 0%.

2. Date palm can withstand relatively high salinity levels in irrigation water without being affected in a way that profit reductions restrict cultivation.

Table 43 Salinity Thresholds and Economic Effects in Selected Crops

Crop	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
Cucumber	1.7	1.1	100.0	100	100
	2.2	1.5	90.0	86	80
	2.9	1.9	75.0	64	50
	4.2	2.8	50.0	29	0
	6.8	4.5	0.0	-42	-99
Squash, zucchini	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	4.7	3.1	100.0	100	100
	5.8	3.9	90.0	81	67
	7.4	4.9	75.0	52	17
	10	6.7	50.0	4	-67
	15	10.0	0.0	-92	
Squash, scallop	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	3.2	2.1	100.0	100	100
	3.8	2.5	90.0	81	67
	4.8	3.2	75.0	52	17
	6.3	4.2	50.0	4	-67
	6.4	4.3	0.0	-92	
Tomato OF	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	2.5	1.7	100.0	100	100
	3.5	2.3	90.0	83	79
	5	3.3	75.0	57	49
	7.6	5.1	50.0	14	-3
	13	8.7	0.0	-71	-106
Tomato PH	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	2.5	1.7	100.0	100	100
	3.5	2.3	90.0	80	50
	5	3.3	75.0	50	-25
	7.6	5.1	50.0	0	
	13	8.7	0.0		
Eggplant OF	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	1.1	0.7	100.0	100	100
	2.5	1.7	90.0	84	82
	4.7	3.1	75.0	61	54
	8.3	5.5	50.0	22	8
	15.6	10.4	0.0	-57	-85
Eggplant PH	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	1.1	0.7	100.0	100	100
	2.5	1.7	90.0	79	-153
	4.7	3.1	75.0	46	
	8.3	5.5	50.0	-7	
	15.6	10.4	0.0		
Sweet Pepper	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	1	0.7	100.0	100	100
	1.5	1.0	90.0	81	61
	2.2	1.5	75.0	54	2
	3.4	2.3	50.0	7	-96
	5.8	3.9	0.0	-85	
Date palm	ECe threshold	ECiw threshold	Yield (% of maximum)	Gross margin (% of maximum)	Net margin (% of maximum)
	2.7	1.8	100.0	100	100
	4.5	3.0	90.0	89	89
	7.3	4.9	75.0	74	73
	12	8.0	50.0	47	46
	21	14.0	0.0	-6	-9

13 Conclusions and Recommendations

1. Within samples of FUs cultivating the same crop, crop management practices sometimes seem to differ to a large extent as shown by the large standard deviations in yield and variable cost. Crop management practices appear thus to have leeway for improvement so as to stabilise average yields. Know-how may play an important part in smoothing out differences between FUs
2. In most cases, the shift from current practice to proposed practice increases gross margins and is therefore beneficial in an economic sense, thus "generating" money to be spent on qualified analytical and extension services.
3. "Proposed practice" in all cases results in improved economic performance as compared to "current practice", which underlines the aforementioned conclusion.
4. Average yield levels in PH eggplant production are higher than in OF, yet average gross margins are lower due to product prices, a fact that shows the variety/quality influence on agricultural profitability.
5. In case produce quality is high enough, produce may be exported and may thus fetch favorable sales prices.
6. The simple fact that gross margins are remarkably high does not in itself justify extended Okra cultivation. Market context and especially labour availability have to be taken into account.
7. A look at the performance of the same varieties of given crops used on different FUs allows for the supposition that there may be leeway for improving productivity in distinct cases.
8. Time series of data would be desirable to see whether the crops which appear to be favourable in the context of the present assessment show a similar level of preferability over a longer period.
9. The difference between fixed cost for PH and OF production gives way to the conclusion that fixed cost in any case must not be neglected when considering overall profitability of a crop.
10. Large deviations between different FUs with regard to a given indicator may be due to varietal or management factors, or may even be influenced by external factors; a larger data basis would be required.
11. The sample is not large enough to allow for qualified conclusions with regard to varietal or crop management influences. As long as the varietal influence cannot be determined, it will be difficult to assess the impact of agronomic recommendations on crop profitability.
12. It might be interesting to follow up with some of the FUs where large productivity leaps are predicted from information in the RW Guidelines so as to see whether yield levels suffer from current fertilisation amounts.
13. Profitabilities as presented above for both irrigation water and N from chemical fertiliser do not represent a steady state; as fertiliser and irrigation recommendations may vary over time, the related profitabilities may also fluctuate.

14. The data basis is relatively weak, in particular with respect to okra, and date palm, as in both cases only two FUs have been monitored. On such grounds any recommendation or conclusion must be placed under great caution.
15. However, in both practices it is okra that appears to generate the highest added value out of irrigation water, followed in “proposed practice” by date palm, cucumber and squash. Tomato figures last (as in “current practice”) with a large difference to the next best crop squash.
16. The results for different weighting scenarios show the overall stability of the ranking that was undertaken. As a general conclusion, yet again under the restriction that the data basis is relatively weak and therefore caution should rule, it can thus be said that okra and date palm production should be extended, at the expense of sweet pepper, squash and eggplant.
17. There is leeway for an increase of irrigation water charges as most of the examined crops would not be affected in a way that their cultivation would become unprofitable: However, a larger data basis would be desirable to examine whether sweet pepper and eggplant have negative gross margins as a general rule or whether seasonal effects are at the foreground for these two crops.
18. The agro-economic effect of increased salinity levels in irrigation water may be largely higher than the agronomic one. In most cases, long-term economic feasibility of the crop (positive net margin) is put at risk long before yields are reduced to 0%.
19. Date palm can withstand relatively high salinity levels in irrigation water without being affected in a way that profit reductions restrict cultivation.
20. Any recommendation with regard to the extension/restriction of any given crop’s cultivation area would require an in-depth market analysis beforehand, as any significant change in production may affect sales prices.