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IMPACT OF IRRIGATION, SALINITY AND CULTURAL PRACTICES ON WHEAT YIELDS

A study of Fordwah/Eastern Sadiqia area, Punjab - Pakistan

Florence PINTUS

ANNEXES

**Report submitted for the obtention of the
Tropical Agronomy Diploma
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H 17553

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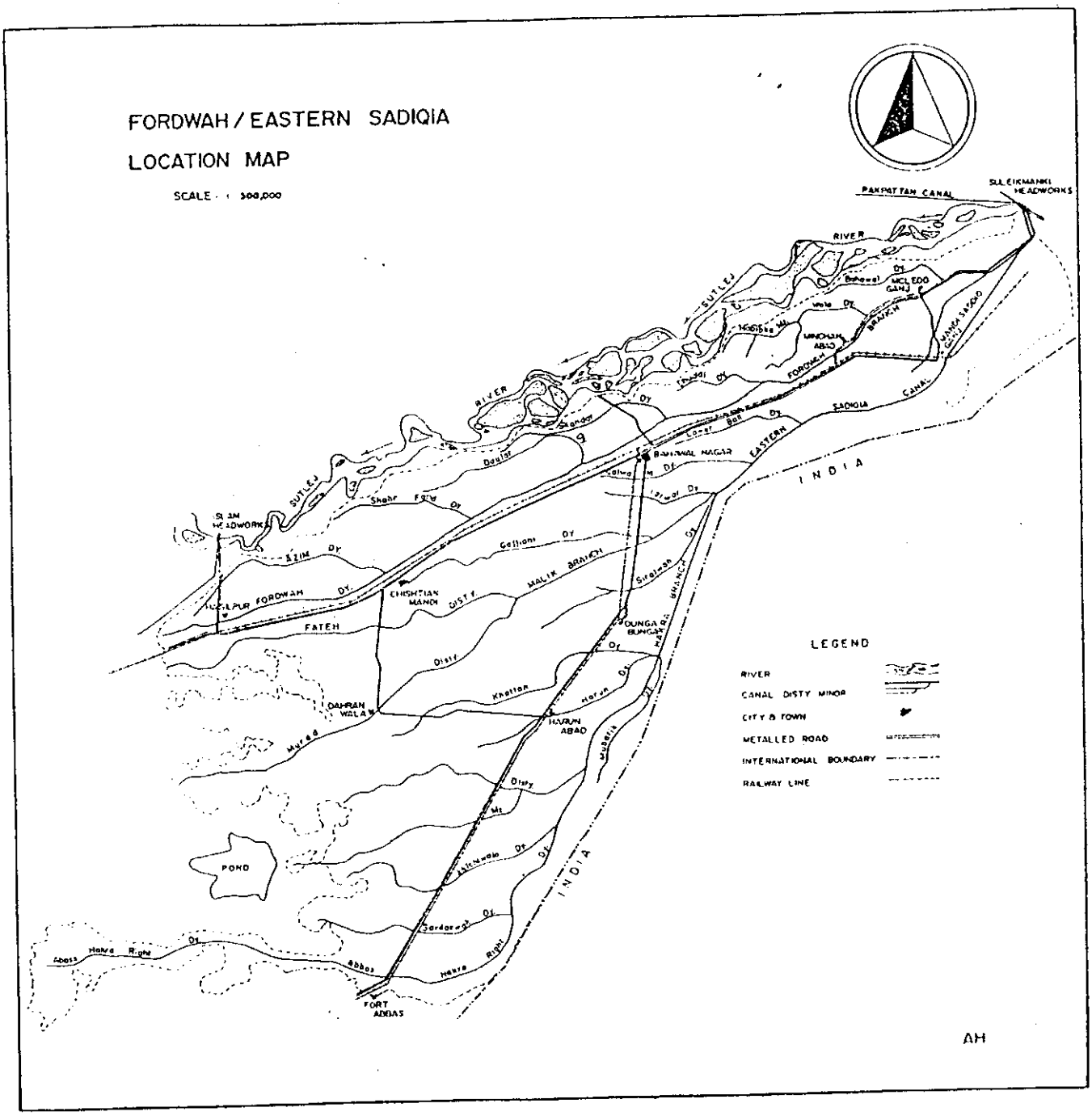
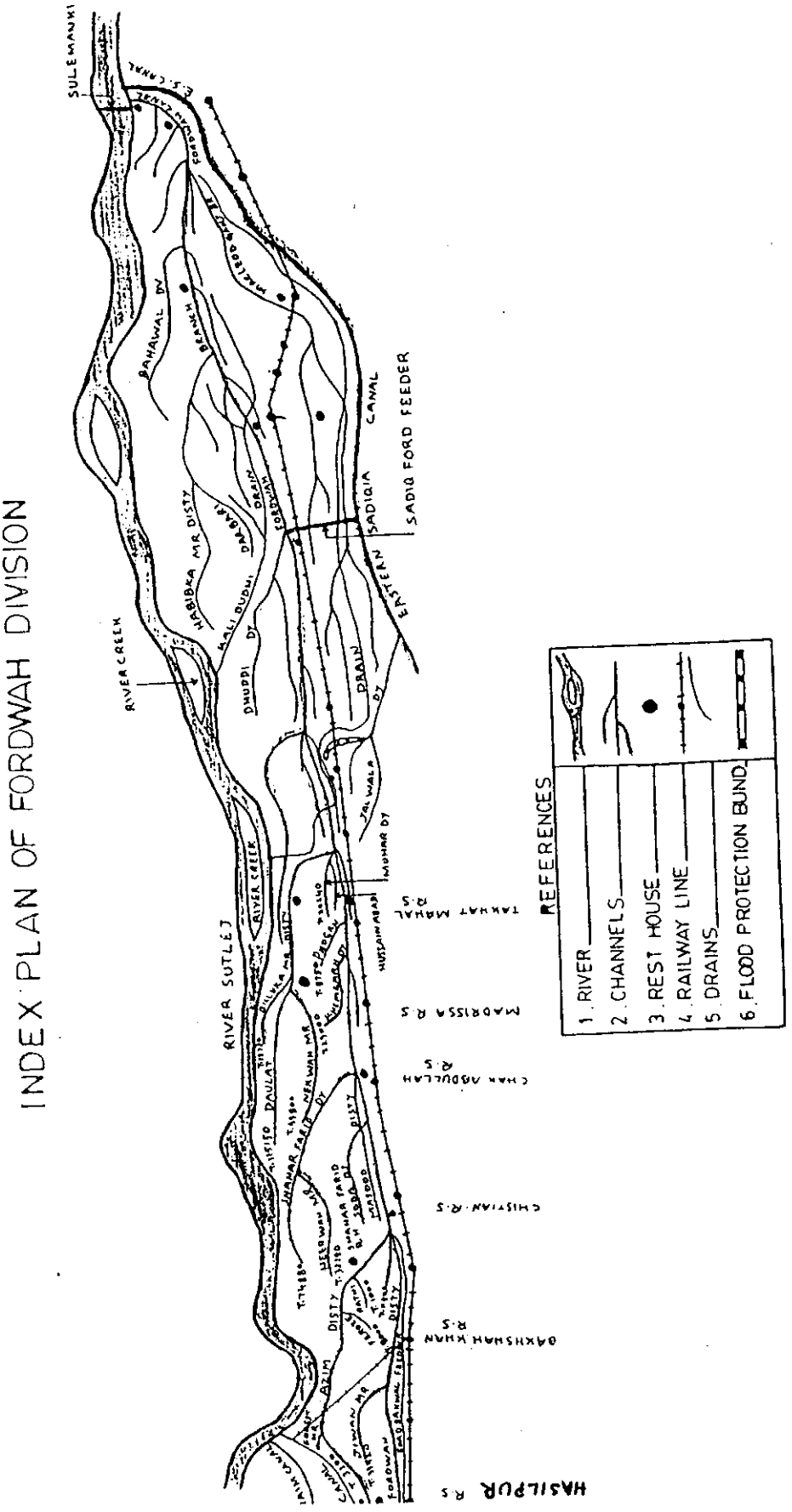
ANNEX 1 : GENERAL MAP OF THE INDUS BASIN IRRIGATION SYSTEM



ANNEX 2 : Fordwah Division index plan



LIST OF ANNEXES

ANNEX 3 : LIST OF SAMPLE FIELDS

Underlined plots were not harvested because data were collected for parallel study.

Table A1 : detail of sample fields.

Farm Number	WC	Farmer's name	Total wheat area (acres)	Plot numbers under wheat	area (acres)	Missing fields	area (acres)
191	A20	Muhammad Irshad	4.44	506/15/24 506/15/23 506/15/18 506/15/7 506/15/13 506/15/22	1 1 0.5 1 0.5 1	no	
208	A111	Abdul Sattar	4.4	193/4/18 193/4/19	1 1	194/1/7 194/1/14 194/5/10	0.9 0.5 1
210	A111	Ghulam Hussain	5.75	173/16/9 173/16/10 173/16/1 173/15/21	1 1 1 1	194/4/21 194/4/22 194/1/2	0.25 1 0.5
213	A111	Muhammad Nawaz	1.5	173/16/2	0.5	<u>173/15/22</u>	<u>1</u>
220	A111	Muhammad Qazi Ali	22	173/11/15 <u>173/11/7</u> 173/12/4	1 1 1	19 left	all are 1acre
66	F14	Shakar Ali	2.75	550/9/11 ooc/41/16	1 0.5	550/9/12 ooc/41/25	0.5 0.75
47	F46	Elahi Bakhsh	11.75	410/11/13 410/11/14 410/11/8 410/12/6	1 1 1 0.5	410/11/3 410/11/4 410/11/5 410/11/6 410/11/7 410/11/9 410/11/12 410/12/2 410/12/5	1 1 1 1 1 1 1 1 0.25
133	F62	M. Siddique Haleem	5	ooc/4 ooc/18 351/16/12 351/16/19 351/16/22 351/16/20	0.5 0.5 0.5 0.5 0.5 0.5	351/16/10 ooc/3 ooc/5 ooc/6 ooc/8 ooc/17	0.5 0.25 0.25 0.25 0.5 0.25

136	F62	Barkat Ali	7.5	351/15/25 351/15/22 351/15/19 351/15/12 351/16/1	0.5 1 0.75 0.75 0.5	351/16/2 351/15/18 351/15/17 351/1516 351/15/24	0.5 1 1 1 0.5
140	F62	Bashir Ahmed	1.5	351/10/24	0.5	351/10/21	1
249	F130	Muhammad Yussaf	7.75	97/2/2 97/2/3 97/2/9 97/2/10 97/2/12 97/2/22 97/2/21	0.5 0.5 1 0.5 0.5 1 1	97/2/7 97/2/11 97/2/19	1 1 0.75
267	F130	Abdul Sattar	1.5	97/2/15 97/2/5	0.5 0.5	97/2/14	0.5
275	F130	Muhammad Islam	14.65	77/13/14 77/13/16 77/13/15 77/13/23 77/13/19 77/13/3 77/13/6 97/1/9	0.9 1 1 0.5 0.5 0.75 0.5 0.5	77/13/22 77/13/5 97/1/2 77/13/2 77/13/8 77/13/13 77/13/17 77/13/18 77/13/25 97/1/3	0.5 0.5 0.5 1 1 1 0.5 1 1 0.5
277	F130	Muhammad Yaqoob	17.4	76/11/17 76/11/18 76/11/24 76/12/5 76/12/4 76/16/5 76/16/1 76/16/20 76/16/15 76/16/16	1 0.5 1 1 1 1 1 0.75 0.4 1	76/16/10 76/11/15 76/11/16 76/11/23 76/11/25 76/16/4 76/16/7 76/16/11 76/16/14 76/16/17 76/16/21 76/16/25	1 1 1 0.5 1 0.5 0.5 0.5 1 1 0.25 0.5
TOTAL				61		3	

Table A2 : List of the samples dropped or that must be considered with care :

Plot Number		Observations
ooc/4	dropped	water data missing
ooc/8	dropped	water data missing
ooc/41/16	dropped	water data missing
506/15/24	dropped	field with two different treatments for each half
97/2/21	dropped	field with two different treatments for each half
76/12/4	dropped	bag lost
76/16/5	dropped	bag lost
76/11/24	dropped	bag lost
351/16/12	Unreliable	This sample bag had the number 351/15/12.
351/15/12	Unreliable	See 351/16/12
351/16/22	Unreliable	This sample bag had the number 351/15/22
351/15/22	Unreliable	See 351/15/22

ANNEX 4 : EXAMPLE OF A PLOT CARD USED FOR THE DATA COLLECTION

First part : harvest of the samples. Notes and observations on the fields.

PLOT CARD

Inquiry number/
Card number /

Date of fieldwork

FARMID — Name of the farmer

Watercourse — Number of the plot

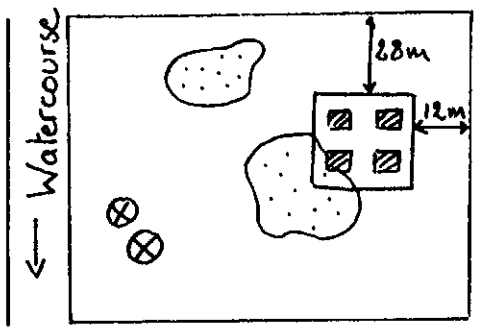
Class (type) — Area (acre)

Variety of wheat

Global aspect of the plot / notice (homogeneous, irregular..)

Geographical position (hill, bottom..)
Laying down spots — Lower size spots

DRAWING OF THE FIELD



North

Legend :

salinity zone

trees

SOIL Structure (+, +/-, -) : very sandy sandy other

Salinity : Y - N Impact on crop No impact on crop

Fertility (++, +, +/-, -)

Weeds (++, +, +/-, 0) Nature of the weeds

Moisture at the moment (+, +/-, -)

Comments :

Second part : components of the yield and wheat yield.

4 M2 CARD

Date of fieldwork

FARMID Name of the farmer

Number of the plot

Area (acre)

Variety of wheat

Sowing dose (kg/acre)

Number of spikes Number of spikes per m2

Total grain weight (g)

Weight of thousand grains (g)

Total number of grains

Number of grains per spike

Dry matter (straws) weight (g) Dry matter weight (g/m2)

Production for this plot (kg)

Final yield **Q/ha**

Note : If not mentioned, all the data concern **four meter square** sample.

Comments :

Yield evolution through time :

Third part : data concerning each plot.

Date of inquiry

FARMID Name of the farmer

Watercourse Number of the plot

Class (type) Area (acre)

HISTORY OF THE PLOT

Spot status : owned rented lent else

(Entry date in the farm Reason)

(Plot origin)

Technical decisions taken by the same person (Y or N)

CULTURAL PAST

Number of years under crop

Lasting of the last fallow (years)

Four last years crops

Nature of the crop	Rabi	Kharif	Comments
year-1 (1994)			
year-2 (1993'			
year-3 (1992)			
year-4 (1991)			

TECHNICAL OPERATIONS

Land preparation

Operation	Date or number of overpasses	Tool, type of traction (harrow, drill...)	Depth (inches)	Comments
Ploughing				
Planking				

Kind of soil wanted for seed bed (lumpy, crumbled...)

Sowing

(- beginning end)

- date of sowing for this plot

- depth of sowing (inches)

- origin : village harvest other

Fertilizer :

Date	Nature	Quantity (kg)	Comments

Every year (Y or N) Sometimes Never

Organic restitution (Y or N)

Weeding (chemical,, frequency..)

Watering schedule

Before ploughing

Date	Origin (TW or WC)	Lasting (minutes)	Discharge (m3/s)	Quantity (m3)	comments
TOTAL					

After ploughing

Date	Origin (TW or WC)	Lasting (minutes)	Discharge (m3/s)	Quantity (m3)	Comments
TOTAL					

Salinity

- date of appearance
- tendency through time
- treatment against salinity
- results

Particular problems

- diseases
- shortage of water
- mineral deficiencies

ANNEX 5 : PLOT CARD USER'S GUIDE

Here follow the meanings of the terms used in each plot card:

DATE OF FIELDWORK : day when the sample was harvested;

FARMID : farm number according to the existing classification (Rinaudo, 1994);

WATERCOURSE : number of the watercourse delivering water to the field;

CLASS (TYPE) : group which the farm belongs to according to the classification (Rinaudo, 1994);

NUMBER OF THE PLOT : defined as Block number/Square number/Kila number (ooc means Out of Command field);

AREA is the area in acres covered by wheat crop;

NUMBER OF SAMPLE : first number is interview day while second number is which farmer interviewed on that day (example, 1-2 is the second farmer interviewed of the first day of fieldwork);
the bottom numbers refers to specific field in the farm (example : 4/6 is the fourth field harvested out of six);

LAYING DOWN SPOTS : yes if wheat stalks are laying on the floor, giving the field an irregular aspect;

LATE SPIKE SPOTS : yes if wheat looks smaller, with smaller spikes size and lower density;

DRAWING OF THE FIELD : global synthetic scheme of the field, featuring sample location, spots and any detail worth writing down.

STRUCTURE AND TEXTURE

The term **structure** designates the way particles are gathered using two levels of observation, macroscopic scale and microscopic scale. The structure determines pores and solid matter space distribution, where part may be occupied by water or air. On this distribution depends fundamental physical properties of the soil (Duchaufour, 1994).
Dimension of lumps have been roughly estimated when broken a first time and a second time. Their consistency was qualified as tough, soft, compact, and open.

But after a while we realized that the results were depending too much on the soil moisture, so the following scale was used:

+: round lumps, about 5 cm diameter, easy to break, with some porosity;

-: sharp lumps, compact and big, inconsistent when broken, slick soil surface;

+/-: between both.

The term **texture** designates the minerals distribution in size classes. Nature and composition of these minerals does not matter. Texture is significant for useful water: it is low in sandy soils, maximum in silty soils. In clay soils, it goes down because of the high wilting point (Duchaufour, 1994).

This parameter has been estimated by touch in wet conditions, with addition of water.

- If friction was felt and sample turned rapidly inconsistent, soil was qualified of very sandy;
- if lower friction was felt, but still inconsistent, soil was qualified of sandy;
- if almost no friction occurred and sample felt like a soft but not too sticky pasta, silty was identified;
- as soon as sample turned consistent and sticky, it qualified as clay, especially if waterlogging was noticed.

These observations have been done for superficial lumps (never deeper than one inch).

SALINITY

This parameter has been visually estimated. White crusts and white salted chips areas left no doubt about white salinity; in tangent cases, soil has been tasted.

Black salinity was harder to identify, especially in extra dry conditions. Most of the time, this factor did not affect the totality of the field though it appears on many irregular spots.

Distinction was made between salinity having an impact on crop and having no impact. First case, crop looks poor and irregular with lower density, smaller size and smaller spike size spots.

Sodicity was not isolated, but often goes with white salinity and leaves no doubt when farmers talk about hard soils.

FERTILITY

According to Soltner (1993), fertility is defined as the soil capacity to grow vegetation; it can be designate as the produce of natural fertility characterized by soil-climate-environment and of agricultural practices. We used this definition, even if it differs a bit from Duchaufour's, and even though its author recognizes it is incomplete.

The main criteria used here was vegetation density (wheat and all kinds of weed), height of the vegetation, health of spikes or fruits and soil cover. The following scale has been used:

+ : when field coverage looked crowded to gorgeous;
- : when low density, poor-looking wheat and empty spaces without any vegetation;
+/- : between both.

WEEDS

Nature and quantity of any weed was identified here. Nevertheless, neither Urdu nor English name existed for these local weeds, so qualifying words have been used:

- artificial weeds (according to field assistant): long, thin, higher than wheat, completely clear white and dry weeds, with small oval pops;
- hairy weeds: medium size, dry, yellow, with a fluffy round flower on the extremity;
- green weeds: all kinds of small green weeds, most of the time remaining under wheat size and pretty dense on the floor. It could also designate long, higher than wheat, scarce green wheat, with a kind of tiny bubbles along the higher third of the stalk.

A (++, +, 0, -) scale has been used here, depending on the density.

MOISTURE

This criteria has been noted to shade structure remarks.

++ : when fingers were wet after touching the soil (scarce),

+ : when moist appeared underneath,

0 : when no moist,

- : when extra dry, tough and large cracks on the surface.

SOWING DOSE in kilograms per acre

NUMBER OF SPIKES per 4 m^2

WEIGHT OF THOUSAND GRAINS in grams

TOTAL GRAIN WEIGHT in grams for 4 m^2

FINAL YIELD in Qx per hectare
The Q/ha figure is approximately the same than in maunds per acre and is easy to translate in tons per hectare since 10 Q = 1 Ton.
It has been obtained by dividing the total grain weight in grams per m^2 by 4, then multiplying it by 10,000 and dividing it by 100,000 for a result in Qx per hectare.

A = total grain weight in grams per 4 m^2,
B = A/4 = total grain weight in grams per m^2,
C = B*10000 = total grain weight in grams per hectare,
D = C/100000 = total grain weight in Qx per hectare.

DRY MATTER WEIGHT in grams per 4 m^2. Includes stalks and leaves.

NOTE: These observations cannot be considered for any other purpose than this study. Indeed, criteria used here have no scientific value since they have been estimated according to a subjective relative scale. Moreover, variability inside a same field is so great that a punctual superficial observation cannot be generalized to the whole area.

The main purpose of these notes were to help conform or not the results obtained later. Figures were compared to each other and when results were not consistent with observations made on the field, they had to be verified or left out. Sometimes they were useful discussions with farmers after the crop had been harvested and ploughed.

ANNEX 6 : ROOTS PROFILES AND COMMENTS

Field observations :

Name : QAZI MOHAMMAD ALI
Plot Number : 173/11/7

Profile was done a few days after harvest, 15 days after the last irrigation.

Soil is mostly loam/silty. It was especially dry and tough when dug, so it was hard to distinguish the roots without destroying them.

This wheat had been broadcasted and sown late (January) because of busy schedule with cotton. Wheat plant density was pretty low; no salinity was identified, roots look poor. Three horizons were distinguished:

- 0 to 15 cm : clear brown soil, pretty tough. Some scarce punctual half-decomposed organic matter presence. Roots are concentrated in this area; going straight down, they are not numerous but strong.

- 15 to 30 : dark brown horizon, still tough. The color is probably due to few humus and loam down migration. The limit of ploughing depth is in this area. Roots are less and thin; ramifications are poor. Some dark purple small spots, looking like mineral concentration, have not been identified.

- 30 to 50 : yellow brown with unwell-delimited grey spots, soft soil. This area was scarcely removed, grey spots were probably due to weak water stagnation. Roots are still visible and pretty strong. Five non-decomposed snails (olive size) have been found.

Hypothesis : This soil looks as if organic matter is migrating to deeper horizons (clear color on the top, darker under. Soil must be well leached (no salinity anymore, but it used to be ten years ago) but organic recharge is missing, upper horizons are getting poorer.

Soil analysis show that Ec never overpasses 4 mmohs/cm in the upper layers and reaches its maximum around 90 cm deep. SAR has also a general trend to increase until 90 cm deep, then decreases slowly. SAR can reach 22 cm at this depth, which confirms that upper horizons are well leached, but a deep impermeable layer keeps water and salt accumulations. It may be a clay layer but nothing is sure about it. Average pH is 8.2, approximately constant from the surface to 2 meters deep.

Belated sowing is probably the principal explanation for root shape: to the opposite of early developed nodal roots, the later developing ones which are thicker, shorter and less branched, decrease effectiveness in water and nutrient absorption (MacKey quoted in Musick & Porter, 1990).

Name : BARKAT ALI
Plot Number : 351/15/17

This soil is the most sandy. It was very tough and dry when dug. Wheat had been broadcasted and density was average. Two holes were done, results looked the same: soil was pretty homogeneous, no distinct colored horizon appeared.

A harder crust was identified on the top of the second hole and soil became softer around 25 cm deep, in this case roots spread underneath. Roots were numerous and concentrated in the first 20 cm, they seemed to be well spread and go a bit deeper in the second grid (over 50 cm). Nothing particular appeared.

Soil analysis showed a regular pH of 8, low SAR (less than 10) and Ec (less than 2 mmohs/cm).

Name : BASHIR AHMED
Plot Number : 351/10/21

Latest irrigation was one month ago, soil was sandy and extremely tough when dug. Wheat had been broadcasted, density was high, soil preparation was very superficial (4-5 inches). No horizon was distinguished.

Tough zone appeared around 25 cm deep, this was probably due to water evaporation limit and soil preparation. Scarce punctual non-decomposed organic matter appeared in the first horizons until 35 cm deep. Soil preparation needs to be studied.

Roots were numerous and concentrated in the 15 first cm, they were less numerous in the tough zone and grew again under until 50 cm deep.

Hypothesis: this sandy soil is missing organic restitution (even though it gets regularly fertilizers) in order to improve its fertility. Humus would help it to save water too.

The hypothesis of low water amount in the Bashir Ahmed profile seems to be confirmed by roots density which increases under conditions of major soil water deficit (Belford et al., 1987).

In this profile, pH is a bit lower (7.9), Ec and SAR are low, but sometimes, around 60-90 cm, they increase suddenly together (until 19 for SAR) without any comprehensible reason.

Name : MOHAMMAD NAWAZ
Plot Number : 173/15/22

Profile was done one day before ploughing. Soil was very moist and, because of clay, very sticky. Water tended to stay on the surface of this field. Wheat had been broadcasted. Two holes were dug, both of them show three horizons, with light variations though.

- 0 to 20-25 : dark-brown horizon, pretty soft. Punctual scarce half-decomposed organic matter presence. Roots are numerous on the top, they are rapidly decreasing. Some dark purple small spots, looking like mineral concentration, have not been identified.

- 20-25 to 30 : a compact line exists around 25 cm deep, just above it a thin dark grey line of extra soft soil takes place (this is obvious only in the second profile). Right under the compact line lays a transitional horizon, light brown with unwell-delimited grey spots, soil is tough. Roots seem to pass the compact tough zone but fade rapidly under.

- 30 to 50 : darker brown with grey and dark spots, tough, compact and sticky soil. These spots are probably due to waterlogging. Roots are scarce and hardly reach 45 cm.

Hypothesis : This soil suffers from deep water stagnation, if not water excess. To the opposite of Bashir Ahmed, roots density would confirm the hypothesis of water excess. Farmer even declared having delayed the first irrigation because of long water leaching after two rainy days (Mehmood, 1995).

Compact line combined with water seems to create a barrier that roots hardly cross. Clay dispersion in the deeper layers in a supposition that nothing has confirmed.

Soil analysis prove that saturation percentage is high (more than 50 percent), especially around 60 cm deep. SAR increases in a very irregular way to this depth but remains in acceptable values (under 10), Ec never passes 1.5 mmohs/cm.

In this case, soil's effects seem to be more physical than chemical, cultural practices can be faulted because the farmer is ploughing only twice, no deeper than 9 inches and does not use any organic fertilizer.

This profile is the only one in which roots do not go more than 50 cm deep, mainly because of excess irrigation amounts combined with soil heavy texture.

ANNEX 7 : DETAILS OF FINAL WHEAT YIELDS AND COMPONENTS

TABLE A3 : DETAIL OF FINAL YIELDS PER PLOT.

	Farmid	Block Number	Square Number	Kila Number	Final Yield (maunds per acre)	Total water quantity (mm)	Salinity
M.	191	506	15	23	31.99	466	0
Irshad	191	506	15	18	16.56	476	0
	191	506	15	7	16.29	438	0
	191	506	15	13	12.78	442	0
	191	506	15	22	19.63	356	0
Abdul	208	193	4	18	16.92	365	1
Sattar	208	193	4	19	29.9	278	0
Ghulam	210	173	16	9	24.48	458	1
Hussain	210	173	16	10	27.3	476	1
	210	173	16	1	34.85	476	2
	210	173	15	21	25.23	490	12
M.	213	173	16	2	32.7	846	2
Nawaz	213	173	15	22	31.04	431	1
M. Qazi	220	173	11	15	52.34	389	1
Ali	220	173	11	7	16.91	438	1
	220	173	12	4	13.86	291	1
Shakar	66	550	9	11	45.44	315	1
Elahi	47	410	11	13	11.68	551	0
Bakhsh	47	410	11	14	20.06	549	0
	47	410	11	8	18.15	625	0
	47	410	12	6	23.6	724	0
M.	133	351	16	12	15.94	438	0
Siddique	133	351	16	19	25.79	452	0
Haleem	133	351	16	22	17.45	370	0
	133	351	16	20	21.03	362	0

Barkat	136	351	15	25	20.02	336	0
Ali	136	351	15	22	16.93	420	0
	136	351	16	1	20.14	548	0
	136	351	15	19	24.22	199	0
	136	351	15	12	13.82	271	0
Bashir	140	351	10	24	23.23	314	0
Ahmed	140	351	10	21	31.24	328	0
M.	249	97	2	2	25.07	235	1
Yussaf	249	97	2	3	5.67	222	1
	249	97	2	9	22.92	211	1
	249	97	2	10	45.38	378	1
	249	97	2	12	21.77	309	1
	249	97	2	22	22.54	238	1
Abdul	267	97	2	15	41.03	267	0
Sattar	267	97	2	5	34.3	459	0
M. Islam	275	77	13	14	41.65	594	0
	275	77	13	16	23.58	594	0
	275	77	13	15	30.94	594	0
	275	77	13	23	33.62	749	0
	275	77	13	19	28	641	0
	275	77	13	3	48.93	554	0
	275	77	13	6	35.13	800	0
	275	97	1	9	29.32	902	0
M.	277	76	11	17	23.95	466	0
Yaqoob	277	76	11	18	34.51	592	0
	277	76	12	5	32.91	480	0
	277	76	16	1	35.09	325	0
	277	76	16	20	36.63	554	0
	277	76	16	15	34.96	647	0
	277	76	16	16	45.7	343	0
	136	351	15	17	14.62	428	0

DETAILS OF THE FIVE BEST AND WORST WHEAT COMPONENTS RESULTS.

The number of spikes per m2 ranges from 95 to 416, i.e. more than four times more.

Table A4 : number of spikes per m2.

Higher number of spike per m2	Plot number	Farmer's name	Watercourse
416	76/16/16	M. Yaqoob	F 130
375	97/2/10	M. Yusaf	F 130
357	76/16/20	M. Yaqoob	F 130
354	76/16/5	M. Yaqoob	F 130
342	173/16/9	Ghulam Hussain	F 62
Lower number of spikes per m2	Plot number	Farmer's name	Watercourse
95	97/2/3	M. Yusaf	F 130
119	351/16/12	Siddique Haleem	F 62
141	351/15/12	Barkat Ali	F 62
166	ooc/18	Siddique Haleem	F 62
170	97/2/9	M. Yusaf	F 14

The number of grains per spike ranges from 12 to 46 grains.

Table A5 : Number of grains per spike.

Higher number of grain per spike	Plot number	Farmer's name	Watercourse
46	173/11/15	Qazi Ali	A 111
44	77/13/14	M. Islam	F 130
43	506/15/23	M. Irshad	A 20
43	550/9/11	Shakar Ali	F 14
43	76/16/15	M. Yaqoob	F130
Lower number of grains per spike	Plot number	Farmer's name	Watercourse
12	506/15/13	M. Irshad	A 20
15	410/11/13	Elahi Bakhsh	F 46
19	351/15/22	Barkat Ali	F 62
18	ooc/18Siddique HaleemF 62		
19	76/11/17	Yaqoob	F 130

The weight of thousand grains ranges from 23,2 to 43,7 grammes.

Table A6 : Weight of thousand grains.

Higher weight of thousand grains (grammes)	Plot number	Farmer's name	Watercourse
43,73	173/15/21	Ghulam Hussain	A 111
43,09	97/2/2	M. Yusaf	F 130
42,20	97/2/9	M. Yusaf	F 130
41,96	ooc/4	Siddique Haleem	F 62
41,85	76/11/17	M. Yaqoob	F 130

Lower weight of thousand grains (grammes)	Plot number	Farmer's name	Watercourse
23,20	97/2/3	M. Yusaf	F 130
23,86	173/12/4	Qazi Ali	A 111
27,67	173/11/7	Qazi Ali	A 111
29,88	351/16/1	Barkat Ali	F 62
30,10	97/2/5	Abdul Sattar	F 130

Variation of straws weight is up to 8 times more than the minimum weight, which is a big difference. But we must stress up here the relative unprecision of this parameter which can concern straws length as well as straws density. Therefore this figure will be considered as an indicator of general wheat growth in order to confort hypothesis, but no supposition will rely on it.

Table 7 : Weight of straws.

Higher straws weight (grammes/m2)	Plot number	Farmer's name	Watercourse
453	76/16/16	M. Yaqoob	A 130
420	173/11/15	Qazi Ali	A 111
412	76/16/15	M. Yaqoob	A 130
378	ooc/4	Siddique Haleem	F 62
368	76/16/5	M. Yaqoob	F 130
Lower straws weight (grammes/m2)	Plot number	Farmer's name	Watercourse
56	76/16/20	M. Yakoob	F 130
98	410/11/13	Elahi Bakhsh	F 46
134	506/15/13	M.Irshad	A 20
141	506/15/7	M. Irshad	A 20
145	351/16/12	Siddique Haleem	F 62

ANNEX 8 : LOCAL RECOMMENDATIONS REGARDING FARMERS' PRACTICES

Abstract of visits to national institutes :

Agricultural Department of Hasilpur
Wheat Institute of Faisalabad (Ayub)
University of Faisalabad
Nuclear Institute for Agriculture and Biology (NIAB) of Faisalabad

National institutes were visited and asked about specific practices in Punjab, recommendations and wheat yields.

Here is an abstract of information collected, classified by operation.

1. Sowing:

sowing	HASILPUR AGRICULTURE DEPARTMENT	FAISALABAD WHEAT INSTITUTE AND NIAB	FAO
dose	45 kg to 60 kg per acre, more in sandy or tough soils, for Inqlab variety and for late sowing	40 kg per acre ; up to 70 kg per acre in sandy soils	44 kg to 56 kg/acre if broadcasted ; 40 kg to 48 kg if sowed with a drill
date	from Nov 15th to Nov 30th	before Nov 15th	
depth	2 to 2.5 inches deeper in dry soils		1 to 2 inches 3 to 3.2 inches in dry soils
effect of late sowing	-10 to 15 kg per acre and per day	- 1% per day	
farmers sowing late (after 1st december)	60 %	60 %	
best varieties	Inqlab 91 Pak 81	Inqlab 91 Pasban	

The recommended sowing dose is 45 kg/acre to 60 kg/acre, whatever the variety. Higher doses are given for belated sowing, saline soils and Inqlab variety (bigger grains' size), because of the lower germination rate.

Average dose for the 64 plots is 51 kg/acre, whereas Doorenbos & Kassam (1992) recommend 44 kg to 56 kg per acre for broadcasting wheat seeds.
The **best period** for sowing -still according to Hasilpur Agricultural Department- goes from November 15th to November 30th. Afterwards, yields decrease from 10 kg to 15 kg per acre and per day. Latest is around January 15th, most of the time delayed because of cotton crop (60% of the farmers sow after December 1st because of cotton schedule).
Depth of sowing should not exceed 2 to 2.5 inches. Doorenbos & Kassam (1992) recommend 2 inches to 3.2 inches maximum in extra dry soils.

2. Rotations

Cotton/wheat (60 percent) and wheat/sugarcane or wheat/rice (40 percent) are the main rotations. This last crop seems to be particularly favorable to wheat because it moisturizes soil and minimizes salinity problems. Sugarcane/wheat and sunflower/cotton are less common, fodder can also be grown in farms where livestock exists.

3. Soil preparation

soil preparation	HASILPUR AGRICULTURE DEPARTMENT	FAISALABAD WHEAT INSTITUTE AND NIAB
number of ploughings	4 to 5 less in sandy soils more in tough and compact soils	1 deep and two normal
depth (inches)	3 to 4 with tractor	up to 60 cm every 4 years in sandy soils because of cementation
number of plankings	2-3	
rotavator	after cotton	

Local recommendations are :

- 4 to 5 **ploughings** with cultivator (before and after sow) from 3 to 4 inches deep;

- 2 to 3 **plankings;**

- **chisel** (12 to 15 inches deep) : only for hard soils;

- **rotavator** is used most of the time after cotton to tear the straws. It does not go deep.

- **mould bold plough** : for silty soils. Used with tractor, it turns the soil upside down on 6 inches. No need in sandy soils.

- **harrow** is used for weeding in wattar conditions (one week after irrigation). According to farmers using it, it breaks weeds but does not decrease final yield. It preserves moisture in the soil (mulch).

4. Fertilization

fertilizer	HASILPUR AGRICULTURE DEPARTMENT	FAISALABAD WHEAT INSTITUTE AND NIAB	FAO
best time	2 applications in clay soils : 50 percent after sowing, 50 percent after first irrigation. 3 applications in sandy soils : 33 percent after sowing, 33 percent after first irrigation, 33 percent after second irrigation.	Before February 15th. 1/3 at the tillering stage, 2/3 at the heading stage. Higher quantities in sandy soils	
Quantities	Potash : 25 kg/acre; Phosphorus : 46 kg/acre ; Nitrogen : 46 kg/acre	Phosphorus : 24 kg/acre ; Nitrogen : 30 kg/acre ; no Potash because enough in irrigation water	Potash : 10-20 kg/acre ; Phosphorus : 14-18 kg/acre ; Nitrogen : 60 kg/acre

Local recommendations give 2 applications in clay soils : 50 percent after sowing, 50 percent after first irrigation and 3 applications in sandy soils : 33 percent after sowing, 33 percent after first irrigation, 33 percent after second irrigation.
Usefulness of this last application can be discussed because fertilizers, and especially Nitrogen, are not efficient when applied after booting (Sebillotte et al., 1978)

- 50 kg per acre for every kind of soil and sowing for Phosphorus, recommended is 46 kg/acre,
- 50 kg per acre for every kind of soil and sowing for Nitrogen, which is a bit higher than recommended (46 kg/acre).
- Decoran, Arilan, Bactril are chemicals against weeds, that are still scarcely used. They are not recommended yet, because effects on crops and soil are not well measured so far.

NB : BIOPOST, from France, is being tested these days. It is supposed to increase the bacteria rate of the soil and so improve its humus tenor (which is pretty low in these area). It should therefore allow a decrease the amount of fertilizers. Three to four bags per acre are adviced, but so far no result have been observed by the farmers.

5. Salinity

- gypsum : 1 ton to 5 tons per acre, depending on the e.c. rate, in one application, rather during summertime (1 bag=50 kg). Afterwards, 15 days of 3 to 4 inches deep waterlogging are recommended to improve the chemical action.

- **Genter** : this crop is grown until 3 to 4 feet high (around 2 months), before mature stage, rotavator buries the crop in the soil to improve its humus. Sometimes, this crop can be used as fodder before being buried.
- **Salinity grass**, Rice, Sugarcane are improving salted soils.
- Black salinity is more harmful for the crops and takes more time to remove.
- SSP and Ammoniosulfate are mostly recommended in these cases
- water application quantities must be bigger.
- sowing is on the top of the furrows.

6. Diseases

- Some are coming from cotton or sunflower (Heliotis), especially the one that provokes shriveled up spikes, but it remains really scarce. It affects yields up to 10 percent.

- Green wheat can be due to late sowing or unwell leveled soil

- **Loosesmut** : brown tiny spots on spikes and leaves : due to humidity. Varieties are plus or less sensitive to it.

7. Irrigation practices

irrigation	HASILPUR AGRICULTURE DEPARTMENT	FAISALABAD WHEAT INSTITUTE AND NIAB	FAO
number of applications	4 to 5 more in sandy soils and in saline soils		
critical stages		crown root initiation/tillering booting anthesis grain filling	late tillering heading anthesis/early grain development
Total quantity	15 inches after sowing 21 inches with rauni irrigation	16 inches with rauni irrigation (400 mm or 1600 m3/acre)	

each application	3 inches (75 mm)	3 to 4 inches less in sandy soils first and fourth are the most important ones	
first irrigation	3 weeks after sowing	20 days after sowing	
interval between irrigations	two weeks	7 days in saline conditions	
effects of brackish water		-1 percent yield reduction per year mixing is better than alternating with canal water (wheat institute) alternating is better than mixing (NIAB)	

ANNEX 9 : Characteristics, objectives, strategies and wheat practices of the 14 sample farms

The farm characteristics description that follows is based on a baseline survey carried out for the sample of 278 farms in 1993. The implicit assumption underlying the use of 1993 data is that farm characteristics (main resources and constraints that determine the strategy) did not significantly change from 1993 to 1995.

Farm characteristics refer to permanent production factors (landholding size, machinery and tubewell, canal water supply which are tightly correlated to the location of the farm within the system) but also to permanent constraints, either physical (salinity), economical (credit constraint) or social (large families). The description of the production in terms of cropping pattern and destination of the production (market or autoconsumption) complements the description of the farm structure. The objective of each farmer and the strategies he implements to achieve them are then briefly described. We will also focus on the wheat strategy and try to analyze it in the global strategy context.

FARM NUMBER : 191 - Mohammad Irshad - Group 3

1. STRUCTURAL CHARACTERISTICS

Total operated area : 11 acres (own), of which 4.44 acres under wheat, all harvested for the present study.

Location in the irrigation system : watercourse Azim 20L, located on a non perenial distributary. Plots in the same square. No salinity.

Water supply : no canal water from November 15 to April 15 (non perenial distributary). Use of own tubewell water.

Cash flow : low non-institutional credit (7190 Rps/ha) that limits inputs and seeds purchase, tubewell use, tractor and labor rents. He receives nevertheless remittance from one family member (Rinaudo, 1994).

Labor : no permanent labor. 1.5 family members labor per hectare. Labor may represent a constraint for cotton weeding and harvest but not for wheat cultivation.

Family members : 13 members.

Investment capacity : No tractor, used oxen and hired tractor.
PTO tubewell owner.

Livestock : 2 oxen. 3.2 Total Livestock Units i.e. 0.7 TLU/ha

2. PRODUCTION

Cropping pattern and rotations :

For 1993/1994		Wheat	Cotton	Sugarcane	Fodder	rice	Other	Total cropping intensity
Rabi	1	27%	-	41%	13.6%	9%	6.8%	47.7%
Kharif	1	-	32%	41%	-	7%	-	81%

Sugarcane represents a significant part of cropping pattern for farms of Group 3. This is This can be explained by a relatively good water supply in Kharif and the proximity of a sugarmill.

Sugarcane is never grown more than 2 years in a row and enters all rotations with wheat. Fallow often goes with sugarcane, because it needs time after harvest either to let plant dry up and prepare

soil for the next crop, or to let it start again for the next season.
Main rotations seem to be :
Sugarcane/Sugarcane / Fodder/Wheat / Fodder/Wheat /
Sugarcane/Sugarcane / Rice/Wheat / Cotton/Wheat /

Crop	Average yield (T/ha)	Production (kg/person)	Percentage sold
Wheat	1.9	184.5	0%
Cotton	0.49		100%

Source : baseline survey (1993)

Total Livestock Unit : 3.2 TLU ; 0.7 TLU/ha

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3. OBJECTIVES AND GLOBAL STRATEGY

The objective of this farmer is to produce wheat for on-farm consumption and to maximize profit with diversification crops (sugarcane and rice).

Sugarcane, vegetables and cotton respectively represent 54.4 percent, 24.6 percent and 7 percent of the total gross return. These figures underline the importance of market-oriented crops in the global strategy. Wheat is only grown for on-farm consumption and represent less than 9 percent of the total gross return of the farm. Wheat strategy is revealed by the low yields and the absence of sales. The area under wheat per family member hardly reach 0.36 and the quantity of wheat per year and per family member is equal to 184.5 kg. The minimum area under fodder is determined by livestock requirements.

4. PRODUCTION RULES

M. Irshad sows wheat as soon as land is free from previous crops, but he is always delayed because of cotton. Even in extremely late situations, he sows fodder before wheat to ensure his animals food. Dead line for sowing wheat is January 1st, but right time is mid-december for him. Even fodder needs to be done before planting wheat because it is essential for animals' feeding.
If late, rauni irrigation will be done during cotton crop. Cotton is usually left late in the field because higher yields are expected.
In general, canal water is preferred to tubewell water for quality and price reasons. Therefore, farmer will prefer to wait a bit longer for canal water to come before giving a tubewell irrigation. This explains why time between rauni irrigation and sowing date ranges from three to five weeks (which is quite big).
After rice, no rauni irrigation will be given because soil is moist, except if canal water is available.

Wheat is grown with the minimum cost per acre (middle variety, minimum input and labor). Thus, when sowed at the end of December, farmer waits for the wheat to boot to see if it is worth applying a second bag of urea per acre. This explains why he does not apply urea on the second irrigation : plant has not boot yet.

5. WHEAT TECHNICAL SEQUENCE

Operations	Average	Variations
- rauni irrigation	weak irrigation (2 inches) with canal water in November.	None if rice before because of soil moisture During cotton if late If fodder before, big irrigation in October and no rauni.
- sowing	own seeds (40 kg/acre) Pak81 or sona leeka variety. Three weeks after rauni, before December if possible, dead line : January first.	- From November 20th (rice/fallow) to December 31st (cotton) - up to 57 kg/acre if sowed late (Dec 26th) because of less germination rate
- soil preparation	before sowing : three ploughings with own oxen and two plankings for a thin crumbled seed bed Higher number if rain during ploughing	- after rice eight ploughings and four plankings because soil is harder. - If late, plankings after sowing and ploughings with rented tractor, but limited due to cash constraint this year. - depth is higher in sandy soils but number of ploughings is less
- fertilizers	- Urea (50kg/acre) during sowing time in dry soil - Urea (50kg/acre) with first, second and third irrigations	- no DAP because too expensive - if shortage of urea, ammonio-nitrate (50 kg/acre) - no urea during the second irrigation if late sowing. Application go up to March.
- weeding	- with hand, between one and two months after sowing	If needed, especially after cotton
- irrigations	4 Total irrigations. Only first irrigation might use canal water, left use tubewell First irrigation : 150 mm after three weeks following irrigations : >= 100 mm, decided according to plant aspect	If rain irrigation a bit delayed First irrigation might be delayed because farmer expects canal water anytime.

6. COMMENTS

This farmer is limited on the amount of tubewell water he can sell because there is a land relief on one side and no waterway on the other. A part of the tubewell water is sold but it is mainly used for his own needs.

For growing sugarcane a sugarmill permit is required that delays the date of cuttings. There might be delay some years also in payment that creates cash problems for farmers.

This year, there were no major input constraints because they were bought and stocked last year. Nevertheless, the farmer ran out of urea and had to use cheaper fertilizer. Moreover, he could not afford to rent a tractor for all his plots to save time, so he was very late sowing.

FARM NUMBER : 275 - Mohammad Islam - Group 11

1. STRUCTURAL CHARACTERISTICS

Total operated area (in command) : 23 acres with 14.65 under wheat crop. Owned 14 acres, nine rented. Nine acres out of command rented out. (5.65 acres owned harvested for the present study).

Location : Fordwah 130, head of watercourse. All wheat plots in two close squares. No salinity.

Water availability : Canal is a constraint from the beginning of Rabi season, but main problems appear from the middle of December to the end of March. Canal water is often mixed with tubewell waters. Average tubewell waters used for the eight harvested fields approximates 93 percent.

Cash flow : high non-institutional credit level (42964 Rps/ha versus 3720 on average for the 278 farms), but no outside remittance.

Family : 12 family members.

Labor: one permanent laborer or 0.43 family labor per hectare.

Equipment : two tubewells, electric and PTO (one shared with four farmers). two tractors (one used for tubewell). One thresher, one cane crusher, land preparation tools (rotavator, etc.)

Livestock : three goats. one oxen. 10 water buffalos.

2. PRODUCTION

Cropping pattern and rotational occupation :

For 1993/1994		Wheat	Cotton	Sugarcane	Fodder	Total cropping intensity
Rabi	1	70%	-	17.4%	8.7%	78.2%
	2		-			
Kharif	1	-	65.2%	17.4%	8.7%	91.3%
	2	-				

1 : crop area in percentage of the total operated area ; 2 : crop area in acre.
Source : baseline survey (1993)

Main crop rotation is wheat/cotton, fodder enters the rotation for a few plots and is grown all year long for livestock feeding (0.5 ha/TLU). Fallow is used on average 6 months every 4 years for part of these plots.

Sugarcane is never grown more than 2 years in a row and is rotated with wheat and cotton on a very few plots. This crop is used as livestock alimentation. Fallow is included in the rotation with sugarcane because it needs time after harvest either to let plant dry up and prepare soil for the next crop, or to let it start again for the next season : Sugarcane/Fallow, Cotton/Wheat, Sugarcane/Sugarcane.

Crop	Average yield (T/ha)	Production (kg/person)	Wheat quantity for consumption (kg/person)	Percentage sold
Wheat	2.78	1501	330	78%
Cotton	1.4			100%

Total Livestock Unit : 8 or 0.86/ha.

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3. OBJECTIVES AND STRATEGIES

PROFIT MAXIMIZATION

Sale and participation in land market through renting in and out are characteristic of this farm.

Part of wheat production is kept for self-consumption and land rent (12 percent of the production, i.e 330 kg/pers), and fodder is grown for livestock.

In parallel, farmer has maximum productions objectives (including wheat since 78 percent is sold) for commercialization. One part of the production goes to sharecropping (sugarcane and wheat), another part is valorized by the livestock (fodder and sugarcane) and another part, which is strongly oriented to market productions (100 percent of cotton is sold), allows farmer to increase his investment capacity, which is a strong characteristic of this group of farmers (credit is high with 42964 Rps/ha).

Buffalos are an important consideration because they represent a high potential revenue.

Farm belongs to the class of high wheat yield and high sales with high level of inputs.

4. PRODUCTION RULES

Obviously, priority is given to cotton at the end of Kharif because there are no labor constraints for picking cotton while wheat planting is delayed. In any case, sowing will be done before the end of December and earlier if possible, because afterwards, wheat is seriously damaged.

In order to increase cropping intensity, time will be saved in all operations, therefore minimum soil preparation will be done and fallow will scarcely be entered in the rotations. For the same reason, and because of no cash constraint, mechanization will be preferred to manual labor.

In general, canal water is preferred to tubewell water and farmer will try to use it at least once on each plot, whatever the period.

A small volume is used for rauni irrigation except if sugarcane was the previous crop or if canal water was used. During the season, a high number of irrigations and large volumes are given due to the sandy soil texture. Total water quantities during Rabi are always higher than 525 mm (the recommended amount).

Irrigations are decided after checking soil and plants. A high number of irrigations is given during March, especially during the grain filling stage because of the heat. At the flowering stage, farmer gives a lower amount of water to avoid first that nitrogen infiltrates too fast in the soil and second that the wind pushes down the plant and prevents the migration of the resources of the plant from the leaves to the grains, which happened this year, significantly lowering yields.

Different tubewells are simultaneously used because of some poor quality water. Because of the sandy soil texture, high discharges are also better to irrigate the fields faster and reduce the infiltrated amount.

Besides, the use of a second tubewell or a third one can be explained by unavailability or malfunction.

Given that this farmer is not facing any kind of cash or water constraint, he always ensures that wheat gets enough water whatever the source.

5. TECHNICAL SEQUENCE

Operations	Average	Variations
- rauni irrigation	end of November, with canal water if available (90 mm)	mixed if few canal water
- sowing time	1 to 2 weeks after rauni irrigation (end of December). Own seeds of good varieties (Pak81) 50 kg/acre	
- soil preparation	rotavator once before ploughing ; ploughing twice with tractor before sowing preferentially ; planking once after sowing	planking twice if soil not enough crumbled ; ploughing twice after sowing if sugarcane before or tough soils. Levelling after sowing if sugarcane was the previous crop.
- fertilizers	DAP (50 kg/acre) during sowing in dry soils. Urea 1/2 bag applied with first irrigation or rain. 1 bag used with the second irrigation. last application used in March after flowering : too late for being used by the plant.	Urea used up to March if late sowing
- weeding	Decoran (0.5 l/acre) if needed, especially after cotton	
- irrigations	Total five irrigations with different tubewell waters mixed. First irrigation 1 to 20 days after sowing, because of sandy soils where water infiltrates more. For that reason, volumes are important.	This year, last irrigation in the beginning of April to try to cure mysterious sickness ; it failed. Volume ranges from 3 to 6 inches. When previous irrigation is more, next will be less and the other way round.

6. COMMENTS

This farmer uses exactly the same practices on his rented plots as on the ones he owns except on the lower performing plots where he asks for one season of fallow. On the third zone he cultivates, the owner uses more fertilizer, especially SSP because of bad hard soil. On these plots, M. Islam

gives less water with a smaller frequency (every two weeks) because the clay texture makes water stay a long time on the surface.

Quantity is no problem for him, but bad quality tubewell water is a constraint for the crop grown the next season.

The farmer still hesitates closing his worst quality water tubewell to try a new one using two water depths (80 feet and 220 feet).

This year, nine water turns were jumped over.

Farmer asserted that he is exhausting his plots. Fallow should be necessary, but his son does not agree.

He is the second farmer in this study waiting for the plant to boot to apply the second urea bag, because he is not sure that wheat will be good. But in this case he uses canal water while he would apply urea systematically with the second and third irrigations, being sure that wheat will grow normally.

FARM NUMBER : 210 - Ghulam Hussain - Group 10

1. STRUCTURAL CHARACTERISTICS

Total operated area (in command) : 10.35 acres cultivated with four rented. 5.75 acres under wheat with four rented and harvested for this study.

Location : Azim 111. Middle of the watercourse. Both sodic and saline area.

Water availability : no canal water for Rabi season. 100 percent of crop requirements covered by tubewells.

Cash flow : high institutional and non-institutional credit (23782 Rps/ha). No remittance.

Labor : no permanent laborer and 0.28 family labor per hectare (low).

Family size : 8 members.

Equipment : one tractor, owner of an electric tubewell.

Livestock : two buffalos, four goats, two cows.

2. PRODUCTION

Cropping pattern and rotations :

For 1993/1994		Wheat	Cotton	Fodder	rice	Salinity grass	Sunflower	Total cropping intensity
Rabi	1	55%	-	5.8%	-			52%
	2	5.75	-	0.5	-			
Kharif	1	-		14.5%	18.8%			64%
	2	-		1.5				

1 : crop area in percentage of the total operated area ; 2 : crop area in acre. (Data 1995)

Wheat is mainly rotated with cotton, but rice is also grown (no more than 2 years in a row) on slightly saline fields.

Salinity grass is used on the most saline fields but is not included in the rotations with wheat and rice.

Fodder represents 0.45 ha/TLU which is quite big. Livestock is actually an important potential revenue for this farmer.

Crop	Average yield (T/ha)	Production (kg/person)	Percentage sold
Wheat	1.28	520	0%
Cotton	1.186		100%

Source : baseline survey (1993).

520 kg per person is more than enough required for self-consumption. Part of the production actually goes to the owner of the fields, as rent.

Total Livestock Unit : 3.1, or 0.44/ha.

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3. OBJECTIVES AND STRATEGIES

Soil quality is the biggest constraint, leaving small choices to this farmer.

His long-term objective is to improve the quality of the soils he owns to the level of those he rents, but water quality and canal constraint do not allow this. Therefore he is reduced to a subsistence objective and wheat production must secure both self-consumption and plot rent to the owner (1501 kg per person are kept).
Besides this subsistence objective, M. Ghulam Hussain has to secure livestock feeding and land sustainability, especially on very saline fields (fields are both saline and sodic). These two last targets give the salinity grass a double valorization. Rice is also grown for soil improvement.

In parallel, farmer has some commercialization objectives since he grows cotton and sells 100 percent of it, but the main constraint for him is the land that determines crop rotations.

He owns very infertile and sodic soils where production is very low and rents, at a very high rate (4000 Rps per acre), more performing fields that he irrigates with rented good quality tubewell water.

Because he is uncertain of the performance of his poor soils, farmer owns important livestock (10 buffalos).

This farm belongs to the low wheat yields (2.8 T/ha on the better rented plots and 1.0 T/ha in the worst fields), low inputs level and no sale.

4. PRODUCTION RULES

Although he is owner of a tubewell, M. Ghulam prefers using a rented tubewell with better water than the one he owns for the fields he rents.

On very saline fields, fodder and salinity grass are grown because yields are poor. On less saline fields, rice is used in the rotations wheat/cotton and wheat is always sown before January.

Being conscious of the poor quality of his soils, the farmer has been testing different crops and varieties to find the most adaptable ones even though yields remain low.

On the long term, more attention is paid to the fields owned, but on the short term priority is given to the fields he rents because they provide essential production yields.

Before applying a second bag of urea, the farmer waits for the plant to boot because it is not worth applying urea to a weak plant.

5. TECHNICAL SEQUENCE

Operations	Average	Variations
- rauni irrigation	last week of November with tubewell. generous volume : 110 mm	less quantity on the saline fields
- sowing	three weeks after rauni : December 20th Own seeds 50kg/acre.	Many varieties are being tested to compare results. Best is Pak81, used on the most saline fields with same dose
- soil preparation	3 ploughings before sowing ; two ploughings and one planking afterwards. four ploughings if tough soil. Rotavator if needed.	
- fertilizers	DAP while sowing in dry soils (50 kg/acre). Urea (25 kg/acre) during the third irrigation (beginning of March)	25 kg/acre on the saline fields instead of 1/2 a bag during the third irrigation
- irrigations	five irrigations with tubewell first irrigation (5inches) after four weeks then every two weeks (4 inches ; 80 mm)	same number of irrigations, same timing, but less quantities (2 inches) because of water stagnation due to sodicity

6. COMMENTS

On the four rented acres, Ghulam Hussain uses amazingly similar practices that are described above. Wheat is rotated with cotton and rice as follows : W / C / W / R / W / R / W / C... These plots are more performing than those he owns but rice is still necessary to counter the effects of salinity. Average yields is 27 maunds per acre, which is consistent with our results. For all of them rent from Qazi Ali tubewell.

There is an obvious evolution in soils texture and performances from South (very saline fields and sandy) to North (slightly saline and more clay)

On the plots he owns, which are both saline and sodic, Ghulam Hussain can hardly grow wheat. Due to sodicity, soils are tough and infertile. Organic matter or clay particles are migrating deep with water because of clay complex destruction.

On the fields he owns, wheat yields are very low (10 maunds per acre), and some do not even germinate (sodic effects). On the most saline, he grows salinity grass and sunflowers, on the other he tries to rotate wheat and rice and uses different practices.

For these plots he uses his own tubewell, with poorer quality water than the one he rents.

Next >>