Zero Tillage Wheat Pilot Production Programme for The Punjab Rice-Wheat System

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Pakistan Agricultural Research Council
Islamabad

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Coordinated Wheat, Barley and Triticale Programme
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THE ZERO TILLAGE WHEAT PILOT PRODUCTION PROGRAM FOR THE PUNJAB RICE-WHEAT SYSTEM

Mohammad Aslam[1], Munir Ahmed[2], N.I. Hashmi[3], M. Qasim Chathah[4] and Van Der Veen[5]

Introduction

The rice-wheat zone of the Punjab covers an area of 1.1 million hectares, where 72% of the wheat is grown in rotation with rice. Wheat yields in this system are low and variable as compared to other cropping systems in the Punjab, (Agri. Stat. 1987). These low yields reflect the special soil condition problems of growing wheat after rice, from the flooded and puddled soil required by rice to the well drained conditions necessary for wheat (Hobbs 1985). Late rice harvest, soil structure and plant residues create difficulties for preparation of a good seed bed for wheat. This results in late planting of wheat mainly using seed broadcast method. Pre-irrigation or rainfall at the time of land preparation further delays planting of wheat by 2-3 weeks in the area. It has been reported by Hobbs 1988 and Randhawa 1979, that delaying the planting of wheat after mid-November causes losses in grain yield at the rate of 1 percent per day per hectare. To address those problems, the coordinated wheat program of PARC and the agronomy department AARI Faisalabad have been conducting zero tillage trials on farmers fields since 1984. The method developed by AARI involves the broadcast of wheat seed when irrigation is applied after the harvest of rice and without tillage. The broadcasting of wheat seed onto untilled land was found to be especially advantageous on heavy, high clay content soils where the zero till drills performance was not satisfactory. PARC has been testing zero till multi crop seeders for wheat sowing. Since 1984 a summary of four years' on-farm trials by PARC Coordinated Wheat Program is contained in Appendix A. Both zero till sowing methods allow the timely planting of wheat and higher yields as well as substantial reductions in the costs of production due to the elimination of the need for land preparation and cultivation.

All of the on-farm experiments with zero tillage drills were carried out with drills imported from New Zealand. The costs of these drills were very high. It was therefore decided to fabricate the drills locally, with the supervision of FMI and financial assistance of USAID.

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1. Agronomist, Wheat Program, NARC; 2. Senior Engineer FMI, NARC; 3. Director Crop Sciences Institute, NARC; 4. Director ORP, NARC; and 5. Consultant MART Project.

The Wheat Programme of ARC, in collaboration with the Operational Research Programme of PARC, the Punjab Agriculture Department and the Farm Machinery Institute, NARC, planned to extensively demonstrate the zero tillage planting in rice-wheat areas of the Punjab using the locally manufactured drills in the 1990 growing season.

Out of ten units of seed drills locally manufactured one was delivered to the ORP and Agriculture Extension Punjab. A set of 3 drills was placed in each district i.e., Gujrat, Gujranwala and Sialkot. A target of 300 acres was set for planting in the rice-wheat area of Punjab. A training programme was organized by Wheat Programme PARC to provide basic know-how about the use of drills and necessary information needed to plant wheat with zero tillage.

Sites were selected by the extension staff of Agriculture Department of the Government of the Punjab while planting was done directly under the supervision of staff from Wheat Programme PARC and ORP. Engineers from FMI PARC were also on hand to ensure the functioning of the drills. Proposed farmer's field days could not take place due to month of Ramzan. All of these activities were funded by the MART Project of USAID under the revised PIL 56.

In spite of all the efforts made only one half of the target set i.e. 150 acres were sown in the target area. Major administrative, financial and technical problems faced during wheat sowing season 1990 are given below:

Administrative Problems

1. *Placement of the Drills*: Drills were placed/distributed too late to start planting at the required time.

2. *Identification of Farmers*: Staff from the extension department had too many things on their minds. They were not able to follow up the project properly.

3. *Mobility of the Drills*: Unnecessary delays occurred because of the need to haul the drills from one farmer to the next. The farms were not clustered and were far removed from each other.

4. *Unavailability of Proper Tractors*: Most of the farmers have medium sized tractors, not able to operate the drill.

Financial Problems

Availability of Funds: Funds were not available when required. Release was late.

Technical Problems Associated with the Operation of Descon No-till Seed-cum-fertilizer Drill

1. The price of the Descon locally manufactured drill is about Rs.60,000 which is beyond the purchasing power of the farmers. Therefore, it is impossible to commercialize this drill on a large scale.

2. The weight of the seed drill is 540 kg excluding the weight of seed and fertilizer. With seed and fertilizer its weight is about 900 kg. This goes beyond the hydraulic capacity of the medium sized (45 h.p.) tractors mostly owned by farmers.

3. Fertilizer distribution system of the drill is not capable of handling fertilizer in the powdered form.

4. Tubeless tires should be replaced with tube tires because tubeless tires are not locally available in the correct size.

5. Coiled type standards or tines were not manufactured with proper spring steel and were not hardened enough. Therefore in the hard soil they got elongated whereas they work fine in loamy soils.

6. The drills were not calibrated properly and in time by the operators/mechanics.

7. The chain-sprockets were not fastened properly and often mis-aligned.

8. Seed and fertilizer spills from the seed and fertilizer box respectively. The boxes need minor repairs.

9. The tractor drivers were not trained in the operation of drills.

10. The drills were not operated with proper size (60 h.p.+) tractors.

This caused following problems:

- Failure of the medium size (45 h.p.) tractors' hydraulic system.

- Damage to drill's drive wheel and tines.

11. Proper operation of drills in the rice fields harvested with combines is difficult, because large rice stubbles stick among the tines creating the hindrance of sowing seed at the proper depth. Extra time is required for the clearance of these stubbles after every pass of the drill.

12. A tool box was not available with each drill. This often delayed minor adjustments and repair work.

13. Spare parts were not made available on site before the sowing season. Late purchase and delivery of spare parts created unnecessary delays.

Farmers' General Attitudes/Experiences with Zero Till Drill

During the study on zero tillage from 1984-88 forty-two farmers were selected in the rice-wheat areas of the Punjab and zero-tillage technology was tested/demonstrated on their farms. These farmers were closely interviewed concerning their views of the technology. At first glance the farmers were always reluctant to give their land for zero-tillage. They always said it might be a bad idea. But after assurance of the researchers, farmers half-heartedly agreed and allowed zero tillage sowing. After a few days, when the crop emerged most of the farmers were still not satisfied because the seedlings were too small and stubbles were too high. After the first irrigation and fertilizer application, the wheat crop grew rapidly and the stubbles started decaying. Farmers then started saying the crop is growing very well but perhaps can not yield well. The time kept on passing and wheat developed stage by stage and it was the time of harvest when researchers and farmers again met and estimated the performance of the plots planted by zero tillage and the plots planted by farmer using his conventional methods. On many of the locations farmers were taken aback that yield of zero tillage was at par/or more as compared to the conventional practices. On the locations where it was possible to plant zero tillage early by saving turn around time the yield of wheat was higher than farmers' yield. This

was the time when farmers started to become convinced that they should plant all their fields with zero tillage because:

a. This technology does not need any land preparation and is very economical.

b. It saves a lot of fuel.

c. It saves wear and tear of the tractor.

d. It saves time as "rauni" always results in late planting.

e. Less weeds grow with zero tillage as soil is not disturbed and early planting of wheat checks weeds.

f. Higher yields result with less hardwork.

When researchers inquired from the farmers whether they would like to plant all their wheat with zero tillage, they answered with confidence "yes"; but inquired from researchers from where they could get a suitable drill for zero tillage.

Farmer Interview

An interview of Ch. Nazir, a farmer of village Arzano on Gujrat-Kunja road, was conducted by Dr. Vanderveen, Dr. Munir Ahmad, Senior Engineer, FMI Islamabad; Mr. Liaqat Hussain, Engineer ORP; and Mr. Mohammad Aslam, Agronomist, Wheat Programme, NARC on August 24, 1991. The following conversation took place:-

Vanderveen: Wheat is the total land you planted to wheat?

Farmer: 31 acres with conventional method and 4 acres using zero tillage.

Vanderveen: At what time did you plant zero tillage plot and conventional plot?

Farmer: It was 30th November for zero tillage plot and completed

his conventional sowing on about 20th December starting from first week of December.

Vanderveen: Which variety of rice have you used?

Farmer: Basmati-385.

Vanderveen: Did you use any insecticide on the rice?

Farmer: Yes; Dielderine only once during crop season.

Dr. Munir: If you or somebody else wanted to hire a zero tillage drill, how much could you pay for an acre?.

Farmer: For planting with zero tillage Rs 120/AC could be easily paid.

Aslam: Did you find more weeds in zero tillage.

Farmer: No, it was not that much weeds.

Aslam: Did you spray herbicide?

Farmer: Nowadays it is not possible to have good weed-free crop without using herbicide.

Liquat: What benefit did you feel from zero tillage?.

Farmer: Fuel could be saved, time for planting is saved, and tractor is saved from wear and tear.

Vanderveen: What yield was harvested from zero tillage and conventional planting?

Farmer: Average from my managed plots was almost 28 maunds/acre and average got with zero tillage was almost 36 maunds/acre.

Aslam: What is the main cause to get late for planting wheat?

Farmer: Rauni method is the main cause for late planting, because rauni, especialy when it coincides with rains (it is obviously a time of rains) delays planting even up to late December.

Vanderveen: How much fertilizer did you use on wheat?

Farmer: One and a half bags DAP at planting and 1 bag Urea applied at first irrigation.

The 1991-92 Zero Tillage Wheat Pilot Production Program

On the basis of past experience and lessons learned, a pilot production program based on Zero Tillage wheat is planned for 1991/92. The objectives of the pilot production program are:

1. Accelerate the adoption of zero till technology i.e.,

   a) design, develop, test and demonstrate a prototype unit of a low cost no-till seed cum fertilizer drill;

   b) involve private manufacturing firms in the commercial production of the no-till drill.

   c) convince farmers, extension workers, government officials and policy makers of the benefits of the zero till sowing technologies and to gain full support of all.

2. Evaluate the benefits derived by the farmers from the adoption of zero till wheat sowing.

3. Determine the major constraints to adoption (i.e., reasons why some farmers are not adopting the new technology) or high yields or reduction in the cost of production. (Pay particular attention to weed and stem borer populations in wheat and rice fields.) and

4. Last but not least, demonstrate the value and feasibility of using zero-till technology over relatively large land areas and involving many small farmers.

Program Policy and Co-ordination Committee

Following membership for the Policy & Coordination Committee is suggested:-

a)	Mr. Ghulam Abbas Jalvi, Director General (AE & AR), Lahore	Chairman
b)	Ch. Maqbool Hussain, Director (Agri. Ext.), Lahore	Member
c)	Dr. N. I. Hashmi, Director (CSI) NARC, Islamabad	"
d)	Dr. M. Qasim Chatha, Director (ORP) NARC, Islamabad	"
e)	Dr. A. Shakoor Khan, Director (FMI) NARC, Islamabad	"
f)	Dr. Muhammad Hussain, Director (WRI) AARI, Faisalabad	"
g)	Dr. M. Munir Nayyar, Director (Agronomy) AARI, Faisalabad	"
h)	Mr. Ghulam Muhammad, Director (Adaptive Research Program), Punjab	"
i)	Mr. Muhammad Anwar Bhutt, Director (RRI) Kala Shah Kaku	"
j)	Dr. M. Khalid, MART Consultant (Agribusiness), PARC, Islamabad	

Technology Recommended for Zero-Till Drill

a) Descon Multicrop Seedmatic Drill (Provided)
b) 60 H.P.+ tractor with good hydraulic system (Hired/rented)

c) DAP at time of planting/sowing (Farmer)
d) Seed of Pak-81, or Pb-85 (Farmer)
e) Seed rate 40-45 kg/Ac (Farmer)
f) Urea top dress at time of first irrigation (Farmer)
g) Herbicide (Dicuran - MA, or Tribunil) (Farmer)
h) Avoid use of drill in heavy soils with high clay contents (Rohi and Rohi Mehrra)
i) Drill in fields with short stubbles and no rice straw
j) Use "Wadwatter" (residual moisture)
k) Sow wheat as soon as possible after November 7
l) Apply first irrigation after 30/35 days of emergence
m) Apply herbicide after first irrigation in wet condition

Program Targets

Locations: Gujranwala and Sialkot

Land Area: 750 Acres

Number of Farmers: 100 (Initial limit of 8 acres/farmer)

Change in yields:
1) No yield loss with zero till if sowing dates are the same.
2) Yields are higher with zero till if earlier planting does occur with zero tillage

Change in costs: Costs reduced with zero tillage up to Rs. 300/Ac as it does not involve any type of land preparation.

Change in profits: Increased by at least Rs 300/Acre

Support Services Needed

1. To convince farmers to participate.

2. To schedule the use of drills.

3. To inform the farmers about the recommendations.

4. To hold field days
   a) at sowing time
   b) soon before harvesting.

5. To study the effect of zero tillage (Director, Pest Warning) trials on stem borer incidents.

6. To arrange repair and maintenance of drills (spare parts, tools and mechanics)

7. To ensure that seed, fertilizers, herbicides, and other inputs will be available from private enterprise in the local markets. (Private firms will also be encouraged to participate in the weed and stem borer trials by providing chemical inputs.)

8. No additional cash is required to adopt new technology at this stage because no-till drills are being provided.

9. Marketing should not be a special concern.

Short Term Strategies For The Successful Operation Of No-Till Drills For The Wheat Sowing Season 1991

The plan is:

1. To bring all the drills either in the Farm Machinery Institute NARC or ORP Workshop Gujrat by first week of September 1991 for repair (Wheat Programme/ORP Gujrat).

2. To identify the parts which need replacement (FMI, NARC Islamabad).

3. To purchase these parts for the current replacement and the replacement needed during the sowing season (FMI, NARC Islamabad).

4. To repair, adjust, and calibrate the drills by mid of October 1991.

5. Site Selection would be done in mid-Oct in the areas by Wheat Programme and ORP (Wheat Programme NARC, FMI NARC).

6. To place the drills at proper locations by 25th of October 1991. (Wheat Programme NARC, ORP Gujrat).

7. To ensure the availability of 60 h.p. or above tractors with good hydraulic system for drilling operation. (ORP Gujrat)

8. To hold training program for tractor operators in last week of October about the operation and maintenance of drills (Wheat Program/ FMI NARC).

9. Director ORP, should depute their mechanics, engineers and operators to work with the mechanics and engineers of the Farm Machinery Institutes during the wheat sowing season 1991, and get themselves acquainted with the repair, maintenance and operation of drills because in future they will be responsible for the operation and repair and maintenance of these drills.

10. Rechecking and recalibration of drills after transport to the locations, before the start of planting.

Long Term Strategies For Design, Development, Performance Evaluation, Local Manufacturing And Popularization Of Low-Cost No-Till Seed-Cum-Fertilizer Drill (1991-1995)

The strategies are:

1. To design and develop a prototype unit of seed-cum-fertilizer drill in the Farm Machinery Institute NARC, which must have the following features:

    a) The drill can be operated with a medium sized (45 h.p.) tractor
    b) The drill price should be about Rs 25,000.
    c) The drill can be manufactured by local manufacturers. This is necessary for the provision of after sales services and spare parts.

2. To test and evaluate the drill in rice-wheat cropping area during the wheat sowing season of 1991 and 92.

3. To demonstrate the prototype unit of low cost no-till drill in working conditions to farmers and local manufacturers during wheat sowing season of 1991 and 1992.

4. To identify potential local manufacturers for manufacturing of drill after successful demonstration of low-cost no-till drill.

5. To assist local manufacturers in manufacturing and popularization of low cost no-till drill.

6. To prepare final report on design, development, performance evaluation and demonstration of low cost no-till seed-cum-fertilizer drill.

Farmer Participation

The participation of farmers will be encouraged by carrying out a number of activities. Deadline for the completion of each activity will be set and verifiable indicators will be specified for ease in monitoring.

	Activities	Deadline Date	Verifiable Indicators
1.	Farmers' meetings to encourage farmers to participate	7 Oct	Form M1 (App. B)
2.	Listing of potential participants and area devoted to rice-wheat	12 Oct	Form M2 (App. C)
3.	Commitment by farmers to devote a specific area to Zero Tillage	15 Oct	Form M2
4.	Farmers' training on technology	30 Oct	Form M1
5.	Transport of Drill to village.	25 Oct	Observation
6.	Scheduling of fields to sow	28 Oct	Form M2
7.	Rechecking of calibration	28 Oct	-
8.	Field days during sowing	15 Nov	Form M1
9.	Field days before harvesting	15 April	Form M1

Involvement of Private Agribusiness Sector in Improving Agricultural Productivity of the Rice-Wheat Area

Importance

Strong linkages between farmers and private agribusinesses have been in existence for centuries. Agricultural R&D organizations in the public sector have established links with the farmers through agricultural extension service. However, their interaction with private agribusinesses has been minimal. This has resulted in a limited impact of R&D work on the development of agricultural production on scientific lines. Input of R&D and extension agencies to the farmers is generally in the form of software i.e. recommendations on varieties, seed rate, row-to-row and plant-to-pant distance, rates and dates of fertilizer application, etc. The farmers after learning about the improved inputs and practices are usually faced with the dilemma of where to get the recommended inputs and how to follow the recommended practices, from where to buy the seeds, which machine will give the desired plant population in the desired pattern and where to buy it.

When field experiments are carried out by R&D and extension agencies, inputs and farm machinery, etc are supplied by the government, most of the time free of cost. Results of these field experiments are usually impressive. R&D scientists get good data, extension people have something to add to their progress report and all is well as far as the public organizations are concerned. But as soon as these agencies leave the experimental sites, the farmers, although they are willing to continue the new practices, are forced to go back to their traditional ways of farming. In short, R&D role in promoting agricultural production on scientific lines has been minimal. This is because of the lack of sustainability in the approach. Sustained high yields will be impossible to achieve without involving the centuries old and stable institution of the private agribusiness sector.

FSR program has taken note of this scenario and is seeking active participation of the private agribusiness sector in its project areas located in different parts of the country. It can be rightly expected that after FSR activities come to an end in an area, relations between the local agribusinesses and the farmers would have developed to an extent that will ensure sustained higher yields and incomes for farmers. In addition, FSR project areas will serve as nuclei around which will grow the modern farms of the country. The country, however, will have to be dotted with such nuclei to develop and accelerate the adoption of appropriate agricultural production technologies suited to the various agro-ecological and agro-economic regions of the country.

FSR activities in the rice-wheat zone of the Punjab have fared well during the last few years. Agricultural technologies have been tuned to suit the local agro-economic and social
conditions of the area.

Areas of Interaction with the Private Agribusiness Sector

Following is a list of major technologies for the rice-wheat area where high level of interaction between research and extension organizations, agribusinesses and farmers can pay high dividends in the immediate future:

1. Direct drilling of wheat in rice stubble

2. Harvesting of wheat with reaper-windrower and threshing with stationary wheat thresher (in vogue)

3. Puddling for rice with puddling rotavator

4. Mechanized rice transplanting with motorized and manual rice transplanters

5. Harvesting of rice with reaper-windrower and threshing with hold-on rice thresher

6. Use of quality seeds, insecticides etc as recommended by the agricultural experts.

Direct drilling technology has proven its superiority over conventional methods of land preparation and will form an important component of the technology package for the pilot project. The direct drills which have been used for experimental work were imported in cbu/ckd condition from New Zealand. For widespread adoption of direct drilling it is essential that these drills are manufactured locally and the machines/services are made available to the farmers at reasonable rates. Farm Machinery Institute of PARC is in the process of adapting the design of New Zealand drill for local manufacture. Farm Machinery Institute will make it available to interested manufacturers and provide technical assistance in its manufacturing and market development. Farm Machinery Institute plans to invite farm machinery manufacturers from Daska, Gujranwala and Gujrat to the pilot project area at the time of wheat sowing with the direct drill so that they may evaluate the performance of the machine and interact with the farmers

to assess its market potential. The manufacturers will also be invited to the project area to see the crop stand and compare it with wheat sown by the farmers following the conventional practices. Finally they will be invited at the time of harvest. This will enable them to see difference in yield and perhaps take supply orders from the farmers and service oriented entrepreneurs. At the time of harvesting , representatives of financial institutions such as ADBP will also be invited to convince the banks to provide credit for the purchase of the machine.

The reaper-windrower for wheat and rice harvesting was developed by the Farm Machinery Institute and was released to the local farm machinery industry for mass production in 1983. Currently, 20 manufacturers are producing 1000 reaper-windrowers annually. A total of 6000 machines are in operation in different parts of the country. So far, the reaper-windrower has found its application in the harvesting of wheat crop as it complements the wheat thresher which has been in use in this country for the last 20 years. Lack of acceptability of reaper-windrower for rice harvesting has been mainly due to the non-availability of a suitable rice thresher. It is not economical for the farmers to harvest rice with reaper-windrowers and yet pay higher than market rate to labor for threshing alone. The Farm Machinery Institute of PARC has transferred the manufacturing technology of a hold-on rice thresher to M/s United Agro Engineers, Daska. The rice thresher is expected to be available to farmers in limited numbers during the coming rice harvesting season. It is hoped that with the introduction of rice thresher, the reaper-windrower will find popularity for rice harvesting.

Farmers use cultivators to puddle fields for rice nursery transplanting. Several passes (more than 5) of the cultivator are required to achieve desired level of puddle. This adds to the puddling cost and time. Studies carried out by the Farm Machinery Institute have shown that it costs less and quality of puddle is also superior with a puddling rotavator. Manufacturers of farm machinery especially tillage rotavators will be invited to the project area at the time of demonstrations which will be carried out by the Farm Machinery Institute in collaboration with the FSR and ORP programs. At present some of the progressive rice farmers are using imported puddling rotavators and their superiority is already established. Efforts are now required to promote their large scale adoption by involving the farm machinery manufacturers to produce these machines locally and market these at reasonable price - - approximately 2 times the cost of a cultivator.

Mechanization of rice transplanting operation has been on the priority list of rice farmers and the government for the last several years. The problem has

aggravated recently because of the dwindling availability of labor willing to hand transplant and that also at half the recommended planting density. The private agribusiness sector is taking interest in this area and one company M/s Guard Agricultural Research and Services (pvt) Ltd, Lahore has taken the lead. During the 1991 rice transplanting season, M/s Guard transplanted 250 acres. They charged Rs. 700/- per acre for this service which included nursery, machinery and labor charges, etc. What farmers had to do was to puddle their fields. The Rice Program of PARC has perfected the technology of low-cost nursery raising. The nursery so raised is suitable for use with the motorized and manual rice transplanters and was successfully demonstrated in the field in collaboration with M/s Guard. M/s Guard is planning to expand its fleet of motorized rice transplanters and is in the process of procuring manual rice transplanters as well. Involvement of M/s Guard and other service oriented entrepreneurs in the project area is planned. These activities will be coordinated by the Farm Machinery Institute and the Rice Program.

In order to ensure continued supply of farm inputs such as seed, fertilizers and pesticides, etc contacts between wholesalers and village shop keepers will be promoted.

The Directorate of Agri-Business Relations of PARC has the mandate to link agricultural institutes with the private agribusiness sector. This Directorate will provide overall coordination for involvement of private agribusinesses in the pilot project.

Monitoring and Evaluation

In general, data are collected on pilot production programs for the following main purposes: 1) for monitoring (assessing project operation); 2) for on-going evaluation of program effects and impacts (assessing project performance) and, 3) for expost evaluation (evaluation after the project is completed) of impact.

Monitoring in the Zero-till Wheat Program

Monitoring is the timely recording and feedback of the activities being carried out in a pilot production program and of problems being encountered.

Monitoring will be accomplished by the regular use of three forms. One

is the Management Information Systems Report (Form M1) (Appendix B) which is to be filled out and submitted weekly. The form contains information on extension and ORP activities, numbers of participating farmers, acres sown and problems encountered.

The second form (M2) is the farmer participation report (Appendix C) which is to be kept current but submitted weekly.

The third form is the Daily Drill Operations form (Appendix D`. A new sheet will be completed each day a drill is used and all the completed forms will be kept with each drill for ease in checking. All the completed forms will be collected at the end of the wheat sowing season for further study.

Schedule of Activities and Budget

Sr. No.	Activity	Tentative Schedule	Estimated Budget, Rs.	Other Facilities Required
1.	Arrange visits of farm machinery manufacturers and representatives of ADBP to the project area during:		20,000 (TA/DA/POL)	Vehicle
	i. direct drilling of wheat	15 Nov 91		
	ii. 1.5 month after wheat sowing	1 Jan 92		
	iii. at wheat harvest time	1 May 92		
	iv. puddling with rotavator	1 July 92		
	v. rice harvesting with reaperwindrower and threshing with hold-on thresher	7 Nov 91		
2.	Prepare protocols for collaboration with the private agribusiness sector and sign agreements of technical assistance	Continuous activity	20,000 (TA/DA/POL)	Vehicle
3.	Establish contacts between wholesalers farm inputs and village shop keepers	Continuous activity	20,000 (TA/DA/POL)	Vehicle

Programme Evaluation and Impact Assessment

Introduction

The impact of the zero-till technology will be assessed in regard to relative yields, costs and net returns in wheat production grown under farmers' methods and grown under zero-till methods. The performance of the succeeding rice crop will also be assessed to measure crop interactions such as increased rice stem borer incidence, seed growth, plant nutrient availability, etc. Farmers will also be interviewed concerning their views of the suitability of the zero-till wheat sowing technology.

Recording Harvest Data

The following yields will be estimated for each participating farmer:

a)	Wheat yields	1)	farmers planting method
		2)	zero-till planting method
		3)	zero-till planting method with recommended herbicide use (a sub-sample of 20 farmers)
b)	Succeeding rice yields	1)	following farmers' method of wheat planting
		2)	following zero-till planting
		3)	following zero-till planting with insecticide for stem borer control.

Yields will be estimated by taking four $3m^2$ samples from each treatment at harvest. Bundles will be wrapped in cotton bags to avoid grain loss, transported to a nearby research station or other site, and dried in the sun. Afterwards they will be threshed with a Winter-steiger plot combine and grain yield/weight will be measured.

Inputs used, Practices Followed and Farmers' Reactions

Each farmer will be interviewed after the wheat harvest and after the rice harvest. The purpose of the interviews will be to determine the types and levels

of inputs used, the farming practices followed (and timing)and the farmers' assessment of the zero-till wheat seeding technology used on the farm. A draft of an interview schedule that can be used in contained in Appendix E.

Estimated Budget for the Zero-till Wheat Pilot Production Program

	Activity	Persons Involved	Days	Budget Rs.
1.	Transport of Drills to NARC	3	4	3200: TA/DA/Hotel
2.	Transport of Drills to NARC	3	4	2000: POL
3.	Transport of Drills to Gujrat	3	2	1600: TA/DA/Hotel
4.	Transport of Drills to Sialkot	3	2	1600: TA/DA/Hotel
5.	Transport of Drills to Gujrat and Sialkot	4	2	2000: POL
6.	Selecting farmers	4	7	14000: TA/DA/Hotel
7.	Selecting farmers	-	7	1000: POL
8.	Actual planting	6	30	80000: TA/DA/Hotel
9.	Repair and maintenance of drills	-	-	30000
10.	Repair and maintenance of vehicles	-	-	20000
11.	Field days	50	4	40000
12.	Miscellaneous	-	-	10000
13.	Stationery	-	-	5000
14.	Training of farmers	50	4	20000
15.	Crop Cut Survey (Rice) 1991-92	6	10	35000:TA/DA/Hotel
16.	Crop Cut Survey (Wheat) 1991-92	6	10	35000: TA/DA/Hotel
17.	Tractor hire 1991-92	8(tractors)	30	120000
18.	Crop Cut Survey (Wheat) 1992-93	6	10	35000
19.	Crop Cut Survey (Rice) 1992-93	6	10	35000:TA/DA/Hotel
20.	Tractor hire 1992-93	-	-	120,000
21.	Data analysis and report writing			50000
		Total		6,60,400

Estimated Funds Required for Design, Performance Evaluation, Local Manufacturing and Popularization of Low-cost No-till cum Fertilizer Drill

	Activity	Funds required (Rs)
1.	Performance evaluation and preliminary demonstration of prototype unit during wheat season of 1991 and 1992.	100,000
2.	Development cost of the drills	250,000
3.	Popularization of locally produced low cost no-till drills.	100,000
4.	Honorarium (for engineers and mechanics)	50,000
5.	Cost for publishing of final report.	50,000
	Total	550,000

ZERO TILLAGE ON-FARM EXPERIMENTS[1] PARC 1984-1988

Introduction

A major emphasis in the experiment program was placed on testing and evaluating zero tillage for growing wheat after rice. It was hypothesized that zero tillage could provide important advantages in addressing the major problems for wheat in the rice-wheat system, including poor land preparation, late planting, poor stands and high land preparation costs. Previous, limited research (Ellis et al. 1979, Sykes 1977, Baliyan et al. 1984) on zero tillage with direct drilling suggested the feasibility of this technology for wheat production. At the same time, it was hypothesized that if zero tillage were impracticable, then deep tillage with a moldboard plow to break up the hard pan after rice might be another way to reduce costs and improve rooting and yield in wheat planted after rice.

Over the four-year period covered by this research program, some 43 experiments were conducted in the study area to evaluate, verify, and demonstrate zero tillage (and to a lesser extent deep tillage). After the early years, when the main emphasis was on evaluating the feasibility of alternative tillage options, the design and focus of these experiments switched to the verification and demonstration of zero tillage, which had by that time proven extremely successful.

Types of Tillage Experiments

In all experiments, zero tillage was compared with farmers' conventional practices. In zero tillage plots no land preparation was done and wheat was planted directly in the standing rice stubble with an Aitchison Seedmatic drill. The farmer prepared an adjacent plot in the conventional manner, usually involving 4 to 8 cultivations and planking, followed by broadcasting of the wheat seed and a further operation to cover the seed. Seed rate, fertilizer levels, number of irrigations, and weed control were constant across treatments and

1 Taken from Chapter IV of "Wheat in the Rice - Wheat Cropping System of the Punjab. A Synthesis of On-Farm Research Results 1984-88", by Mohammad Aslam et. al .; PARC/CIMMYT Page No. 89-3.

followed official recommendations. In the 1984-85 experiments, the zero tillage plot was planted when the farmer planted the rest of the field. Half the sites had been previously planted to IR-6 rice and half to Basmati rice. In later years zero tillage planting was done as soon as feasible after rice harvest, regardless of when the farmer planted. The selection of sites favored fields previously planted to Basmati rice (by that time grown on 85% of the rice land in the study area).

After the promise of zero tillage for rice-wheat systems became clear, later experiments were designed to test important implications of this new technology. Specifically, 1986-87 and 1987-88 experiments compared broadcasting of nitrogen fertilizer on the surface to placement with the drill. Later studies also explored the possibility of zero tillage on wheat affecting the following rice crop, since the intact rice stubble provided a potential breeding ground for the rice stem borer.

Summary of the Results of Zero Tillage Experiments

Table 1 summarizes information on grain yield and tillers/m^2 across 42 locations and four years of experiments. In 1984-85, farmers tillage gave significantly higher yields than zero tillage, a fact explained by the researchers' inexperience in managing seed depth, fertilizer application, and row spacing with the new drill (which was originally set to the conditions of New Zealand, from where it had been imported). In 1985-86, conventional and zero tillage were compared on larger plots at 15 locations for similar planting dates, and resulting yields were not significantly different. In 1986-87 and 1987-88, zero tillage produced significantly higher average yields than conventional tillage across 19 sites--probably due to the fact that in those years zero tillage plots were planted on average 24 days[1] before the farmer's crop.

Table 1 also shows that in three of the four years of experiments, wheat under zero tillage with direct drilling produced a significantly higher number of tillers/m^2 than that under conventional tillage.

Over all 42 sites and 4 years of experiments (Fig. 1), zero tillage provided only 6% higher yields, a non-significant difference. However, in the last two years of experiments when planting dates were allowed to differ between treatments, zero tillage yields were 24% higher than those obtained under conventional practices. Moreover, the principal expected outcome of zero tillage was not to increase yields, but rather to reduce farmers' land preparation and

1. The time required to perform conventional tillage operations

planting expenses and thereby enhance the profitability of the rice-wheat system, an objective which it certainly achieved.

Table 1. A comparison of the effects of zero tillage and farmer practices on wheat yield and tillering at 42 locations in on-farm experiments, 1984-88

Year	No. of locations	Grain yield (kg/ha) Zero tillage	Farmers' practice	Significant	Tillers/m² Zero tillage	Farmers' practice	Significance
1984-85	8	3032	3275	5%	264	275	n.s.
1985-86	15	3600	3516	n.s.	253	232	1%
1986-87	13	3791	3509	2%	260	236	3%
1987-88	6	4279	3560	1%	290	261	8%
Average	-	3675	3465	n.s.	267	251	n.s.

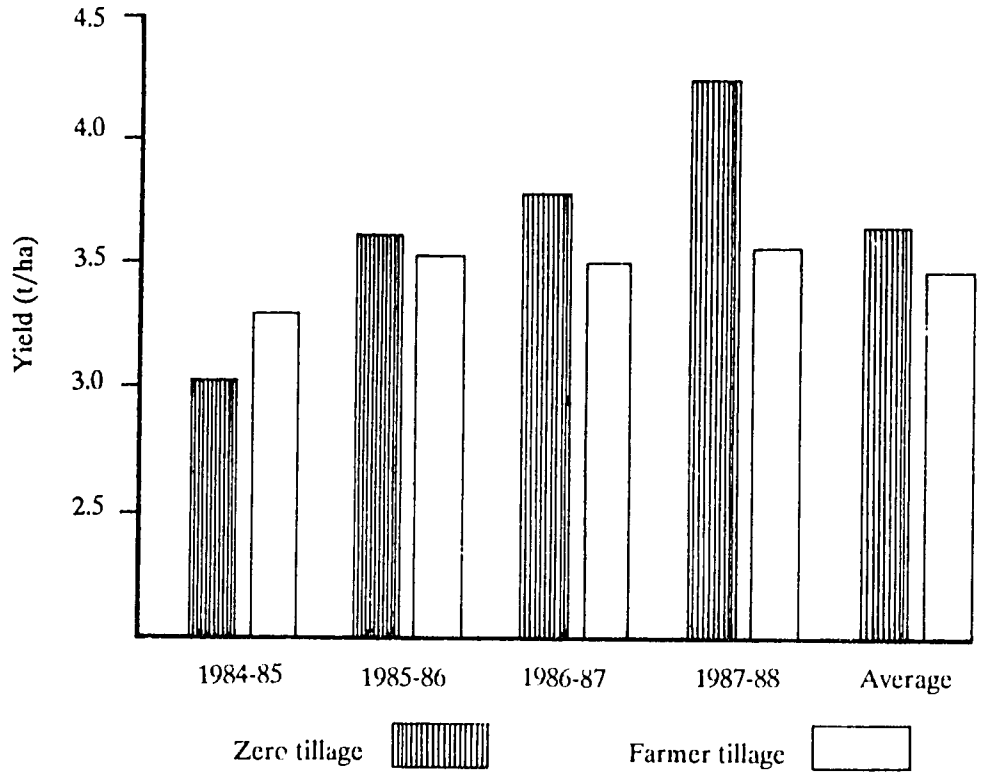


Figure 1. Comparison of the effects of zero tillage and farmer tillage on wheat yield during 1984-88.

Comparison of zero and conventional tillage at recommended and late planting dates

In the 1985-86 cycle, 5 of the 15 locations were planted at the recommended time (early-to mid-November) and 10 were planted late (mid-December). Results presented in Table 2 show significantly higher grain yield for the zero tillage treatment than that of conventional tillage for sites planted at the recommended time. However, for late planted sites there was no significant yield difference between treatments. There were 16 % more tillers/m^2 in zero tillage plots planted on the recommended date. The longer growing season provided by planting in November apparently enabled better tillering under zero tillage.

Table 2. A comparison of the effects of zero tillage and farmer practices on wheat yields and tillering at recommended and later planting dates, 1985-86.

	Recommended planting (5 locations)		Late planting (10 locations)		Average	
	Yield (kg/ha)	Tillers/m^2	Yield (kg/ha)	Tillers/m^2	Yield (kg/ha)	Tillers/m^2
Zero tillage	3782	236	3509	263	3600	253
Farmers'practices	3267	204	3460	246	3516	232
Significance	1%	2%	n.s.	n.s.	n.s.	n.s.

The Effect of zero tillage at different planting times

In 1986-87 and 1987-88, planting date was varied with treatment. Zero tillage plots were planted as soon as possible after the harvest of Basmati rice, regardless of when the farmer planted the rest of the field. At six sites this resulted in zero tillage plots being planted an average 24 days earlier than the conventional tillage plots (Table 3). At the other 7 locations, the difference in planting was only 3-4 days (Table 4).

Data on yield for each tillage treatment are summarized in Tables 3 and 4. As would be expected, at the six locations where the difference in planting date were 10 days or more, significantly higher yields were obtained on the zero

tillage plots than on the conventional tillage plots. The average yields gain at these locations was 25%, equivalent to 30 kg/ha for every day's delay in the date of planting or about 1% per day. These results are consistent with other studies which address the effect of delayed planting on wheat yields (Hobbs 1985).

Table 3. The effect of zero tillage on planting date and yield, 1986-87.

Location	Yield (kg/ha)		Days*
	Zero tillage	Farmer practice	
Mundir Sharif	4245	2660	33
Ashraf Maujianwala	2689	2198	22
Daska site-1	3842	2735	13
Daska site-ll	3143	3209	10
Daska site-lll	3838	3420	44
Ahmad Nagar	4308	3526	20
Average	3677 a	2598 b	24

* Days difference between zero-tillage planting and farmer practice.

Table 4. The effect of zero tillage on yield with planting date held relatively constant , 1986-87.

Location	yield (kg/ha)		Days*
	Zero tillage	Farmer practice	
Aslam Gujrat	3909	3770	4
K.S.K.farm (early)	5543	5306	3
Sheikhupura	3113	3575	5
Ahmad Nagar	4320	4791	0
Ashraf Maujianwala	3770	3739	3
K.S.K.farm (late)	3225	4391	5
Daska	3334	2297	5
Average	3888	3981	4

* Days difference between zero tillage planting and farmer practices.

At the seven locations where planting dates varied little between tillage treatments there was no difference in yields between the two treatments.

Effect of zero tillage on plant emergence and weed population

In 1985-86, plant density and weed population data were collected soon after emergence. As shown in Table 5, seed planted under zero tillage had 19% better emergence than that planted using conventional methods, since in the latter case seeds are sometimes buried too deeply to emerge. Even more significant were the 43% lower weed densities observed when direct drilling was used in place of conventional methods. This can be explained by the fact that conventional land preparation disturbs the soil, bringing new weed seeds to the surface, and that the rice stubble and higher wheat seeding densities found under zero tillage simply leave less room for weeds.

Table 5. Effect of zero tillage on plant emergence and weed population, 1985-86

Method	Plants emerged/m² (11 locations)	Number of weeds/m² grasses (6 locations)	broadleaf	Total
Zero tillage	114	59	54	113
Farmer practices	96	72	90	162
Significance	<5%	<5%	<5%	7%

Effect of fertilizer placement and timing in zero tillage plots

Table 6 summarizes the results from two locations in 1986-87 where three methods of nitrogen application were compared in zero tillage plots: 1)placement with the drill at the time of planting, 2) broadcasting at the time of planting, and 3) broadcasting with the first irrigation. In all cases, phosphorus was applied by broadcasting at the time of planting but not incorporated.

Nitrogen placement at planting and broadcasting at the first irrigation gave equivalent results, whereas broadcasting at planting resulted in significantly lower yields (Table 6). It is likely that volatilization of the nitrogen broadcast under dry conditions resulted in significant nitrogen loss. These results support other evidence from Pakistan and elsewhere showing that nitrogen can be conveniently broadcast at the first irrigation without any loss in yields (Majid et al. 1988).

Table 6. The effect of method of nitrogen application on yield and tillering under zero tillage, 1986-87.

Fertilizer application method	Tiller/m²	1000 grain weight (gm)	Grain yield (kg/ha)
Placement with the drill at planting	244 a	41.31 b	4784 a
Broadcast at planting	218 b	41.7 b	4094 b
Broadcast with first irrigation	253 a	47.6 a	4581 ab
Significance	5%	5%	5%

Figures followed by different letters are significant at 5% level using DMRT.

Economics of alternative tillage methods

Although zero tillage with direct drilling in the experimental program was performed by an imported drill, this drill could easily be adapted and manufactured in Pakistan at considerably lower price. In consultation with agricultural engineers, it was estimated that a locally adapted and manufactured device suitable for direct drilling would cost Rs.30,000 to 35,000, compared with about Rs.12,000 for currently available rabi drills; that is, direct drilling with a locally produced device would entail roughly double the expense of conventional drilling practices. However, because the former technology eliminates all land preparation costs, overall saving in the case of sowing wheat come to 87% (Rs 700/ha) of the cost of conventional planting methods (Table 7). In addition, if direct drilling results in wheat being planted an average of 10 days earlier, an additional yield of 300 kg/ha, valued at approximately Rs600/ha, would be obtained.

Thus, whereas deep tillage resulted in yields comparable to those for conventional tillage and also reduced land preparation costs, direct drilling with zero tillage was much more economical.

Discussion

Direct drilling with zero tillage has considerable potential for the rice-wheat rotation. Its major advantages are reduced cost of cultivation, more timely planting, and uniform fertilizer distribution. This technology also appears to reduce weed populations and improve crop stand, as a result of the more uniform and proper seed placement obtained with direct drilling.

Table 7. Economic comparison of zero tillage and farmer practices for wheat cultivation.

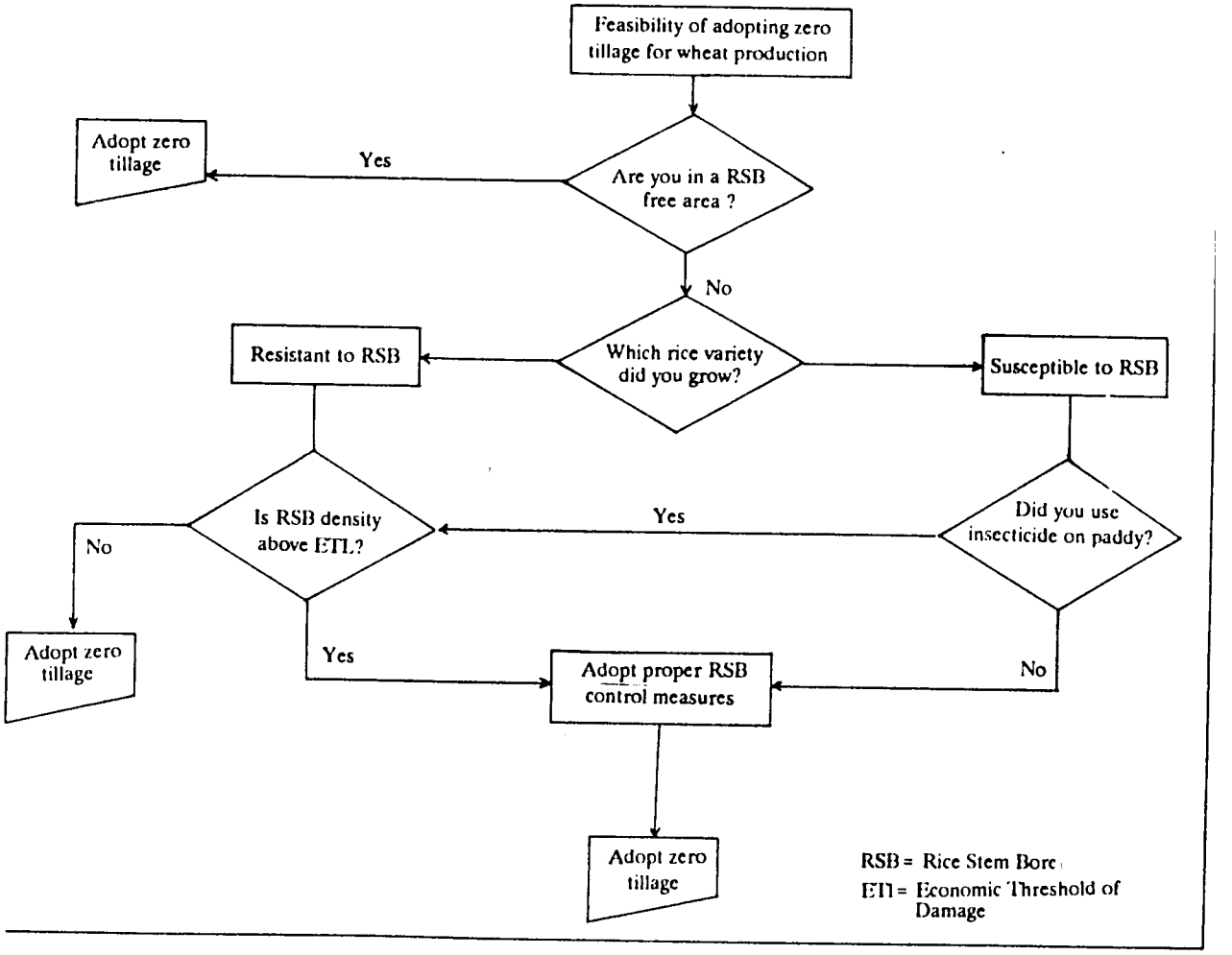
Operation	Cost in Rupees/ha	
	Zero tillage	Farmer practices
Land preparation		
6 Cultivations @Rs75/ha	-	450
3 Plantings @ Rs50/ha	-	150
Cost of planting		
2 Cultivations and 1 planting	-	200
Drilling	125	-
Broadcasting	-	25
Total	125	825

Cost advantage of zero tillage over farmer practices	= 825 - 125	= 700
Benefits of zero tillage through early planting 20 days (av.) at 30 kg/day/ha	= 600 x 2	= 1200
Total benefits of zero tillage over farmer practices		= 1900

Source: Wheat Programme, NARC, Islamabad.

A potential constraint on adopting zero tillage for wheat is the stem borer (*Scirpophaga incertulas*), currently an important pest of rice. Farmers are presently required by law (Insect Pest Control Act 1959) to uproot and incorporate rice stubbles by the end of February and to delay planting of rice nurseries until after May 20th in order to destroy the larvae surviving in the rice stubbles before rice planting begins again. Based on research conducted in the 1940s and 1950s, the law is very loosely enforced (Inayatullah and Rehman 1987). Many fields are left with rice stubble after the February limit, including fields sown to berseem (which is nearly always planted directly in standing rice stubble), low lying fields left fallow because they cannot be plowed and poorly prepared wheat fields where much stubble remains on the surface. Rice stem borer larvae survive in these fields. Against this background and with the possibility of implementing zero tillage in wheat production, an integrated approach to stem borer control that combines cultural and chemical methods is required.

Figure 2 presents a model for adopting zero tillage which takes into account key questions faced by farmers when making such a decision. However, implementing this model requires further research on the rice stem borer, upgrading extension advice on stem borer control, and changing the Pest Control Act to reflect current realities.



ure 2. Suggested model for adoption of zero tillage.

Management Information Systems Report
(To be filled weekly)

Form M1

Location _____

Period _____ to _____ Responsible Person _____

	This Report	Total Last Report	Total (1+2) To date
Extensions and ORP activities			
Number of farmer meetings			
Total number of farmers attending			
Number of farmers agreeing to participate			
Total number of acres committed			
Number of farmer training sessions			
Total number of farmers attending			
Number of field days			

(Cont'd)

(Cont'd)

	This Report	Total Last Report	Total To Date
Number of farmers attending			

Number of participating farmers and area sown

Number of farmers participating			
Number of acres sown to 0 Till			

Problems* encountered

Topic	Definition and cause	Action taken	Action recommended
Drill breakdown			
Shortage of participating farmers			
Lack of herbicide and insecticide			
Other (a)			
Other (b)			

*Serious problems should be communicated to the coordinator by telephone or other means as soon as possible for corrective action.

Appendix C

Zero Tillage Wheat Production Program

Farmers Participation Report

Form M2

Village _____ Person Responsible _____

Column 1 Names of farmers willing to participate	Column 2 Acres devoted to rice-wheat	Column 3 Acres committed (Max 8 acres) Acres sowing date	Column 4 Area Sown to Zero Tillage 1st date of sowing	2nd date of sowing

DAILY DRILL OPERATIONS

Drill Number _____ District _____ Tehsil _____

Date _____ Operator/Supervisor _____

Time of Day From	Time of Day To	Activity* (repair, transport, seeding, rest period, idle, etc.)	Kilometers if travelling	Farmer's Name	Acres Seeded	Acres ID No. or loc.	Sq No.	Village	Tractor Owner	Signature

* If repairs were needed, explain the problem _____

Action taken _____ Parts replaced _____ Parts repaired _____

Location of repair _____

Time required to install the part of repair the drill _____

Time required to purchase or repair part _____

Appendix E

Farmers' Practices Interview Form

Date: _____

Farmers name: _____ Village: _____

Name of interviewer: _____
Total acres farmed _____
Owned _____ Rented _____ Both _____
Conventional _____

Size of parcel:
0 Till _____

Crop: _____

Variety:
0 Till _____
Conventional _____

Planting date: 0 Till _____ Conventional _____
Harvesting date: 0 Till _____ Conventional _____

How much seed did you use for this crop on the parcels?
0 Till _____
Conventional _____

Where did you get the seed? 0 Till _____ Conventional _____

What was the cost of the seed? 0 Till _____ Conventional _____

Did you apply any compost to this crop? Yes ____ No _____

If yes, how many carts? 0 Till _____ Conventional _____

Did you apply any chemical fertilizer to this crop?
Yes _____ No _____

If yes,

Kind of fertilizer used	Quantity Used (in kg)	Fertilizer Cost (in Rs.)
Basal		
O Till		
Conventional		
Top dress		
O Till		
Conventional		

Did you use any other chemicals on this crop?
Yes _____ No _____

If Yes, what kind? 0 Till _____ Conventional _____

How much did it cost? _____

Did you receive irrigation for this crop?
Yes _____ No _____

If Yes,
when? _____

What was the source of irrigation?

_____

How does the yield of this crop compare with the crop you had on this parcel last year?

0 Till
Decreased _____ Same _____ Increased _____

Conventional
Decrease _____ Save _____ Increased _____

Do you plan to plant more of your wheat following the no till method next year?

Explain: _____

_____

What are the main advantages of the zero till system?

Explain: _____

_____

Are there any disadvantages to the zero till system?

Yes_____ No _____

Explain: _____

_____

_____