NATURAL RESOURCES SYSTEMS PROGRAMME

PROJECT REPORT[1]

DFID Project Number

R7830 and R7839

Report Title

Improved livelihood and environment through deep summer ploughing in rice based cropping system of heavy soils of Eastern India.

Annex Bix of the Final Technical Report of projects R7830 and R7839.

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NRSP Production System

High Potential

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CONTENTS

Summary

Rice-wheat is the major cropping system of Bihar. Rice is mainly established through transplanting in puddled field, which impedes the percolation losses of nutrients and irrigation water, and favours rice growth. However, destruction of soil aggregates due to puddling in rice increased soil strength in surface and sub-surface layers, decrease hydraulic conductivity and infiltration and inadequate charging of the soil profile for the crop following rice. Regular use of zero tillage followed in puddled field will drastically change the bulk density and creates a compact zone. This impedes the movement of air, water and nutrients in the soil profile for the crop following rice This hardpan/compact zone must be broken regularly through deep summer ploughing (DSP).

Project area is distributed representatively in the villages *Nisarpura, Gopalpur, Amwan and Badauli, Aspura* under Right Parallel-5 distributary of Sone command in Patna district of Bihar.. On-farm Demonstration of DSP with rice followed by wheat and other winter crops have been conducted in participatory mode at head, middle and tail sections of RP Channel –5 of Patna canal during kharif (wet) and rabi (winter) seasons of 2001- 2002 and 2003.**.** Twenty-four acres of land (6 acres, 2.42 ha composite plot each) were brought under deep tillage. In 2002 without any support from the institute, 43 more farmers adopted DSP in 12.4 ha land and the rice crop was planted in wet season. In 2003 another 23 ha lands were brought under DSP by farmers themselves. In 2004, DSP covered 57.□ha in project area and around 117 ha in adjoining areas. Feedback from farmers on how they view the DSP/tillage practices on plant health and crop yield was gathered. This information indicates that farmers are assessing the practices from a range of viewpoints relative to their usual practices including land preparation and sowing costs, quality of crop establishment, weed growth and species composition, pest and disease incidence.

All DSP treatments have given higher yield over conventional tillage systems. Maximum rice grain yield of 57.94q/ha was recorded under deep summer ploughing (DSP) with secondary tillage of bullock drawn ploughing (twice) for puddling. There was additional income in all DSP treatments due to deep summer ploughing. An additional income of Rs. 5170/ha was achieved under DSP with direct planking for rice transplanting on account of increase in yield as well as saving in cost of cultivation. It was observed that diseases, insects, and weeds never crossed the threshold limit in DSP whereas non-DSP fields were infested badly. The weed load is much lower in DSP fields Similarly; Nematodes population was drastically restricted under DSP. Deep summer ploughing (DSP) helped to break the compact zone generally formed due to puddling. Thus there was no yellowness of wheat crop after first irrigation, which normally happened under conventional tillage. Participatory budgeting with the farmers and Cirrus Management Services (team member of R7□39) revealed that DSP reduced the cost on tillage, weeding, pest control and increased yield. At the beginning of DSP only 72 percent farmers were having positive opinion but by the end of the season none were having negative opinion and there was drastic change of attitude from reluctance to partial agreement and finally on self paid tillage operation by May,2002.

1.0 Introduction

The soils in project area of DFID are heavy in nature. Farmers practice is mainly rice based cropping system and face difficulty/problem in cultivation due to compact soil. Rice is mainly established through puddle transplanting. Puddling in rice-wheat system impedes the percolation losses of nutrients and irrigation water and favours rice growth. However, destruction of soil aggregates due to puddling in rice increases soil strength in surface and sub-surface layers, decreases hydraulic conductivity, and infiltration and inadequate charging of the soil profile for the crop following rice (Prihar *et al.,* 1995). A proper tillage would be one that fulfills all these considerations at a reasonable cost and at the same time produces the best yield (Khan, 19□4). The hardpan/compact zone must be broken regularly through deep summer ploughing (DSP). The DSP has been found also to reduce the incidence of insect pest, disease and weed. Betterment in soil physical properties, increase in water holding capacity and higher yield of crops due to DSP have been reported by several workers (Khan *et al.* 2002a,b, Meelu et al, 1979 and Kar, 1995) in other climatic conditions.

1.1 Rationale

Recently, the various stakeholders in Bihar are popularizing zero tillage sowing of rice and winter crops especially in wheat and lentil in order to facilitate sowing at right time. However, regular use of zero tillage followed in puddled field will drastically change the bulk density and creates a compact zone (Khan *et al.* 2002a). This impedes the movement of air, water, and nutrients in the soil profile and it is significant especially in south Bihar where, soil is heavy and difficult to plough when dry. Therefore to have sowing at right time for wheat and improved physical conditions of soil in succeeding rice, deep summer ploughing during summer in zero tilled fields is vital. In addition, the information on crop performance and farmers response to DSP for assessment of large-scale uptake is negligible. Based on experiences elsewhere it was felt that DSP may be evaluated at the farmers fields of Bihar and its large-scale uptake could increase the efficiency of land productivity by increase in yield and also reduction in cost of production. However the performance of the technology under farm conditions in Bihar is poorly understood.

On farm demonstration on deep summer ploughing followed by secondary tillage operations for rice and wheat and other winter crops was undertaken in farmer's fields located at different reaches of the canal . The selected fields are located in between villages to ensure wide exposure to the farmers.

1.2 Project Area

Project area is situated between □4^0.51' N Latitude and □4^0.55' E Longitude and is distributed representatively in the villages Nisarpura, Gopalpur, Amwan and Badauli under Right Parallel-5 distributary of Sone command located in *Bikram and Naubatpur* blocks of Patna district of Bihar. Apart from the aforesaid villages, few more villages (i.e. *Aspura and Chanderi*) were also taken for DSP studies during 2002-2003. The project area is under alluvial plain of Indo-Gangetic basin. The gross command area is 3022 ha and cultivable area is 2203 ha.

The rainfall varies between 911- 105□mm. It is uniform plain land sloping towards Northeast. Average ground slope is 0.5m/km. The texture varied from silt loam to silty clay loams in up lands and silty clay loams to clay loams in low lands. The soils fall under great group Paleustalf, Haplaquents.

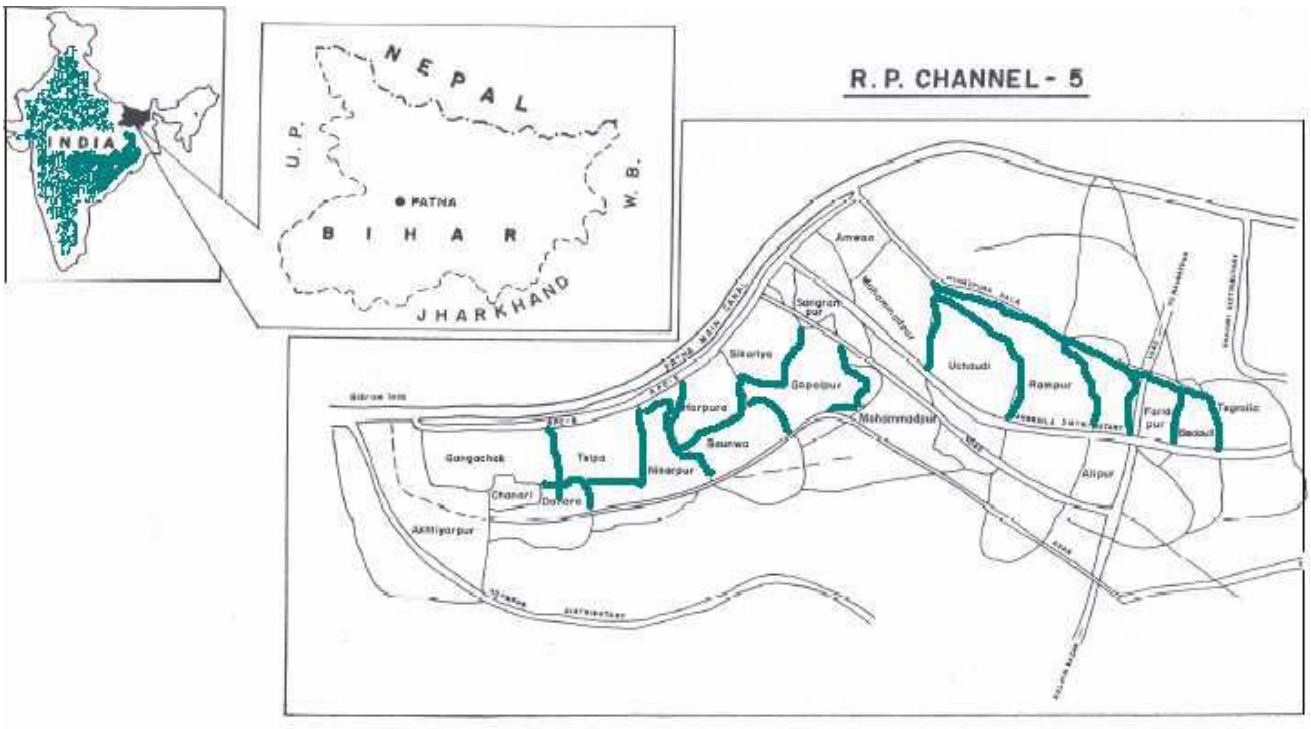

Fig.1 Project area under deep tillage

1.3 Genesis of Problem and Approach

The farmers of this region experience difficulty in field operations for wet season rice and poor yield and winter crops after wet season rice. Farmers expected some solutions to their problems from the scientists working in their region. Team of scientists tried to analyze the problem and found increased bulk density/compaction as one the reasons, which hinder the conductive environment in the seed/ root bed due to continuous conventional practice, increase the load of implements etc., on the soil and increase compaction year after year. To bring the soil physical environment to its original position, regular deep summer ploughing (DSP) may be one of the best options. After the harvest of winter crops during April, most of the fields are left uncultivated and if soil is ploughed upto 30 – 45 cm which will remove the insulting layer from the deep layers and expose the darker more energy absorbing soil to the sun to absorb solar energy which will help in reducing/killing the weeds and insects apart from loosening the soil and bring back the original bulk density of the soil.

The aforesaid idea was initially not appreciated by the farmers. The benefits and methods were explained to the farmers group and individual but non of them came forward to adopt directly. On the principle of believing by seeing it was decided to adopt on-farm demonstration. The practice of DSP was again discussed with farmers group. Then they agreed to join on participatory basis. The farmers agreed to bear all cost in the demonstration except deep summer plough. Then four sites were selected in compact block. In one block 2.42 ha land was put under DSP, which were owned by 11 to 42 farmers. The sites were in such a way that it could facilitate wide exposure to majority of farmers. Thus total 24 acres land was puddled under DSP at 4 sites covering 6 farmers' fields at head, middle and tail sections of RP Channel-5 distributary of Patna canal of Sone command of Bihar. The plots were not only monitored but also information from farmers on how they view the deep summer ploughing was gathered. The information indicates that farmers were assessing the practices from a range of view points relative to their usual practices including land preparation, sowing costs, quality of crop establishment, weed growth and species composition and pest & disease incidence. By May 2003, the second season for deep summer ploughing, there were no farmers against DSP and there was a drastic change in farmer's attitude from total reluctance to partial agreement and finally they were more than willing to go for DSP with self-resources and payment.

Given that much of the agriculture in this area is not mechanized and farmers are resource poor and mostly do conventional bullock drawn farming, deep ploughing implements like mould board and disk ploughs are currently not-available either with the farmers or in the market. Given this situation the challenge that faced the project was to promote its adoption both to local farmers and service providers.

2.0 Materials and Methods

Recognizing the current constraints to adoption of the technology and recognizing the power of believing by seeing it was decided to adopt on-farm demonstration for DSP. The practice of DSP was again discussed with farmers group. Then they agreed to join on participatory basis. The farmers agreed to bear all cost in the demonstration except deep summer plough. Deep summer ploughing (DSP) with tractor drawn disc was done in four villages having silty loam, silty clay loam, silty loam, and silty clay loam soils, respectively during May, 2001 and in *Aspura and Chaderi* during May 2002 (Fig. 1). These villages were chosen in head, middle and tail sections of RP distributory channel - 5 of Patna canal in Sone canal command area of central Bihar, India. Twenty-four acres of land (6 acres, 2.42 ha composite plot each) were brought under deep tillage. Farmers were advised to reduce secondary tillage in DSP fields. Uniform rice was taken in wet season following puddling treatments. According to their facility and initial mindset, farmers' adopted 3 type of secondary tillage in their field i.e. only planking, tractor puddling, bullock drawn, ploughing (twice) for puddling. In non-DSP fields conventional tillage (bullock drawn ploughing 4-6 times) was done.

Rice seeds were also directly broadcasted in the plots of heavy soil (Plate 3) where secondary tillage is getting unexpected interaction with soil texture in seedbed preparations. After harvesting of rice, winter crops like wheat, lentil, and gram were sown in normal ploughed

fields or wheat through zero-tilled machines without ploughing. Farmers adopted three types of winter season tillage practices under rice-wheat system. The farmers' choice was also studied. Monthly reaction of all 6 farmers in 2001 - 02 under DSP was recorded till crop harvest of rice. Opinion of farmers who are adopting DSP, labours and non-DSP farmers were also taken and presented in Fig. . Effect on yield, saving in cultivation, additional income, and gross benefit due to DSP were recorded. Participatory budgeting for DSP was done in two villages. Opinion and reaction of farmers of project area as well as adjoining villages were also recorded during and after the winter season crops using structured schedules in group meetings. Crop growth, ease of cultivation, time saving and less pests and weeds were some of the important observations felt by them.

The agriculture in this area is not mechanized and farmers are resource poor and mostly do conventional bullock drawn farming, that's why deep ploughing implements like mould board and disk ploughs are currently available neither among the farmers and in the market. One disc plough for demonstration and evaluation was provided through DFID project fund to the farmers for entire area. Operations of disc plough were done through group contact, and live demonstration of the equipment.

In 2002 without any support from the institute, 43 more farmers did DSP in 12.4 ha land and the rice crop was planted in wet season. The farmers started feeling necessity of tillage practices, and service providers among them were encouraged with this emerged opportunity. The farmers reaction about DSP and observations on plant health and yield were observed.

Plate.1: Deep tillage practice in study area by using disc plough

3.0 Results and Discussion

3.1 Effect of deep summer tillage on rice yield and economics

All DSP treatments have given higher yield over conventional tillage systems. Maximum rice grain yield of 5.□ t/ha was recorded under deep summer ploughing (DSP) with secondary tillage of bullock drawn ploughing (twice) for puddling. This treatment was closely followed by DSP with only planking at rice planting where 5.7 t/ha yield was recorded. Conventional tillage (bullock drawn ploughing 4-6 times) for puddling could yield only 5.0 t/ha. DSP with tractor drawn puddled field yielded 5.2 t/ha (Table 1).

All DSP treatments have required lower total cost of operation under land preparation, transplanting and weeding than conventional tillage systems. Minimum cost of Rs. 4951/ha was incurred under DSP with planking only for the land operations, transplanting and weeding. It was as high as Rs. 60□2/ha under conventional tillage. DSP with twice bullock drawn puddling costed Rs.5393/ha, which was less than conventional tillage. In DSP with tractor drawn puddling Rs. 569□/ha was needed under aforesaid three operations. Thus, there was saving of input due to DSP (Table 2).

There was additional income in all DSP treatments due to deep summer ploughing. An additional income of Rs. 4447/ha was incurred under DSP with direct planking for rice transplanting on account of increase in yield as well as saving in cost of cultivation. Lowest additional income of Rs. 1216/ha due to DSP with tractor drawn puddling was observed. The values recorded (Rs. 4□15/ha) under DSP with bullock drawn ploughing (twice) were also higher over DSP with tractor drawn puddling (Table1).

Cost of input under tillage treatments in rice at various reaches in the canal distributary for the kharif (wet season) 2001 and 2002 are reported in Table 2a and 2b. Economics of tillage treatment for DSP during 2002 is also presented in Table 2c. The rice yields at various reaches in canal distributary under varying tillage treatments during kharif (wet season) 2001 and 2002 are presented in Table 3a where DSP was done during May 2001 and also in Table 3 b & Fig.2. where DSP was done during May 2002.

Table 1.Yield and economics of tillage treatment in rice cropping at various reaches in Canal distributary (RP Channel-5) of sone command, Patna (India)

Tillage treatment	No. Of sites	Mean yield (t/ha)	Saving in tillage, planting and weeding (Rs./ha)	Saving in fertilizer (Rs./ha)	Income through increased yield (Rs/ha)	Gross benefit (Rs./ha)
Deep Summer Ploughing (DSP) + tractor puddling	40	5.2	152	232	1216	1600
DSP + only planking at rice planting	06	5.7	723	40□	4447	557□
DSP + bullock drawn ploughing twice for puddling	54	5.□	306	3□3	4□15	5504
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	16	5.0	-	-	-	-

Price of rice grain and straw is Rs. 500 and Rs.50 per quintal, respectively. (As per local market).

Table 2a. Economics of tillage treatment in rice cropping at various reaches in Canal distributary (RP Channel-5) of Sone command for the year 2001 (DSP during May, 2001)

Tillage treatment	Cost of input (Rs./ha)					Total
	DSP	Puddling	Trans-planting	Manual weeding	Fertilizer	
Deep Summer Ploughing (DSP) + tractor puddling	1500	1673	1213 (24.3)	400 (□)	912	569□
DSP + only planking at rice planting	1500	1215	1100 (22.0)	400 (□)	736	4951
DSP + bullock drawn ploughing twice for puddling	1500	1707	1025 (20.5)	400 (□)	761	5393
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	-	24□□	1200 (24.0)	1250 (25)	1144	60□2

Mandays/ha have been given in parentheses. Labour wage is @ Rs. 50/day.

Table.2 b. Economics of tillage treatment in rice cropping at various reaches in Canal distributary (RP Channel-5) of Sone command, for the year 2002 (DSP during May,2001)

Tillage treatment	Cost of input (Rs. /ha)					
	DSP	Puddling	Trans-planting	Mannual weeding	Fertilizer	Total
Deep Summer Ploughing (DSP) + tractor puddling	-	2170	1375 (25)	550 (10)	912	5007
DSP + only planking at rice planting	-	1670	1320 (24.0)	660 (12)	736	43□6
DSP + bullock drawn ploughing twice for puddling	-	2210	1210 (22.0)	440 (□)	761	4621
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	-	22□□	14□5 (27.0)	1375 (25)	1144	6292

Labour wage Rs. 55/day

Table.2c. Economics of tillage treatment in rice cropping at various reaches in Canal distributary (RP Channel-5) of Sone command, for the year 2003 (DSP during May, 2003)

Tillage treatment	Cost of input (Rs. /ha)								
	DSP	Puddling	Trans-planting	Manual weeding	Fertilizer	Pesticide & fungicide	Total	Income from increased yield	Total benefit from yield & savings
Deep Summer Ploughing (DSP) + tractor puddling	1500	1673	1320 (24)	440 (□)	912	--	5□45	1216 (52 %)	329□
DSP + only planking at rice planting	1500	1215	1210 (22.0)	440 (□)	736	--	5101	4447 (57%)	7773

DSP + bullock drawn ploughing twice for puddling	1500	1707	1210 (22.0)	440 (□)	761	--	561□	4□15 (5□%)	7124
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	-	24□□	1320 (24.0)	1375 (25)	1144	1600	7927	------ (50%)	------

Labour wage Rs. 55/day

Participatory budgeting with the farmers and CMS(NGO Partner) revealed that DSP reduced the cost on tillage, weeding, use of pesticides and increased yield. Total cost incurred was Rs.3360=0 compared to Rs.5560=00/ ha in conventional while additional income obtained in DSP was Rs.500/q grain, total benefit was Rs.6200=00/ha.The exercise was done in two villages: Gopalpur and Nisarpura during 2001.(Tab.4&5). Regular opinion of all □6 farmers was recorded on monthly basis during crop season. At the time of DSP 72 percent farmers were having positive opinion, which was reduced to 57.0 per cent by the time of rice transplanting, and negative opinion increased from 15 to 33 per cent. However, at Tillering stage the positive opinion increased to 64 per cent. Finally, the negative opinion was almost nil at rice harvest. Difficulty in land preparation at transplanting stage was the reason for negative opinion. There was no farmer against DSP and there was drastic change of attitude from reluctance to partial agreement and finally on self paid tillage operations by 2003.

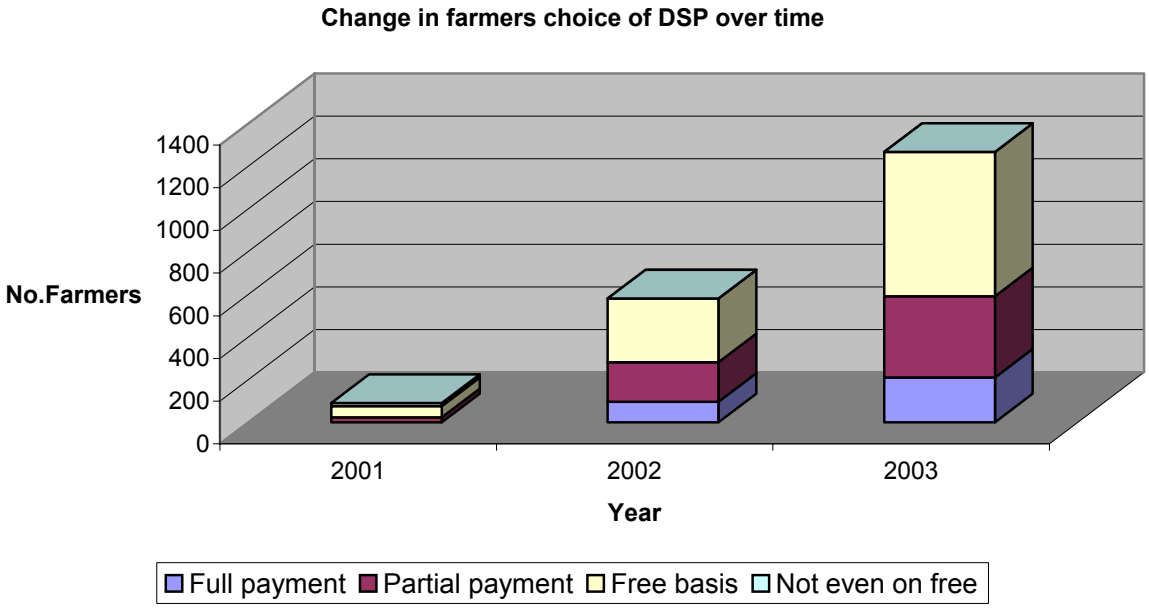

Fig.2 Change in farmers' choice of deep summer ploughing over time

Table 2d. Economics of rice cultivation under DSP in RPC –5 (2003)

Tillage practices	Input cost (Rs./ha)								Yield q/ha	Income (Rs./ha)	Profit (Rs./ha)
	Tillage	Land preparation	Transplanting	Weed control	Fertilizer	Insecticide	Fungicide	Total input			
C.T	1090	195□	954	702	753	110	0	5593	34	16□45	11350
D.S.P.	□22	106□	□90	367	5□5	0	0	3□02	42	20901	17100
Profit in DSP	267	□90	73	276	1□□	110	0	1791	□	4569	5750

Participatory budgeting on DSP

In the participatory budgeting with the farmers and NGO (CMS) it was found that DSP was found to reduce the cost on tillage, weeding, use of pesticides and increase yield. The exercise made in two villages (Gopalpur and Nisarpura) is presented in Table 4 and 5.

Table 4. Participatory budgeting of DSP in village Gopalpur (1 Bigha = ¼ ha)

S.N.	Activity	Normal tillage	Deep tillage
1.	Summer ploughing	No	One summer ploughing @ Rs. 300/Bigha
2.	Land preparation for transplanting	Five ploughing @ Rs. 750/Bigha	One ploughing @ Rs. 300/Bigha
3.	Transplanting	6 man power Rs. 240=00	6 man power Rs. 240=00
4.	Weeding	20 man power half time Rs. 400/Bigha	Nil
5.	Insecticide/Fungicide/Herbicide etc.	Rs. 400/Bigha	Nil
6.	Yield	25 mond/Bigha (10q)	30 mond/Bigha (12q)
7.	Total cost in ploughing, land preparation and weeding/Bigha	Rs.1390=00	Rs. □40=00
□	Additional income by yield	-	1000=00 @ Rs. 500/q grain
9.	Total benefit/Bigha	-	Rs. 1950=00

Farmer's: - Ramashis Sharma, Bipin Bihari Sharma, Rajnandan Sharma, Dev Nayak Sharma and Bipin : Facilitator: - ICAR - RCER and Cirrus Management Services

Table.5. Participatory budgeting of DSP in village Nisarpura (1 Bigha = ¼ ha)

S.N.	Activity	Normal tillage	Deep tillage
1.	Summer ploughing	Normal ploughing twice by tractor Rs. 225/Bigha	One summer ploughing @ Rs. 300/Bigha
2.	Land preparation for transplanting	Four ploughing @ Rs. 450/Bigha	One ploughing @ Rs. 250/Bigha
3.	Transplanting	6 man power Rs. 240=00	6 man power Rs. 240=00
4.	Weeding	6 man power Rs. 240/Bigha	3 man power Rs. 120/Bigha
5.	Insecticide/Fungicide/Herbicide etc.	Rs. 400/Bigha	Nil
6.	Fertilizer	60 kg/ Bigha Rs. 4□0=00	40 kg/Bigha Rs.320=00
7	Yield	26 mond/Bigha(10.4q)	2□mond/Bigha(11.2q)
□	Total cost in ploughing, land preparation and weeding/Bigha	Rs.1635=00	Rs. 1230=00
9.	Additional income by yield	-	400=00@ Rs. 500/q grain

10.	Total benefit/Bigha -	Rs. 1205=00

Farmer's: - Vijay Shankar, Niranjan Kumar, Manish Kumar, Santosh Kumar;Facilitator: - ICAR - RCER and CMS

Table 6a. Effect of tillage treatment on rice yield at various reaches in canal distributory (DSP during May 2001)

Tillage treatment	No. of locations	Yield Range (q/ha)	Mean yield (q/ha)	
			2001	2002
Lower Head Reach (Village: Nisarpura)				
Deep Summer Ploughing (DSP) + tractor puddling	□	66.21 – 30.43	53.7□	56.75
DSP + only planking at rice planting	1	56.65	56.65	57.1□
DSP + bullock drawn ploughing twice for puddling	□	75.□3 – 42.46	64.63	5□23
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	4	57.60 – 46.06	53.39	49.00
Middle Reach (Village: Gopalpur)				
Deep Summer Ploughing (DSP) + tractor puddling	3	57.31 – 49.90	52.74	5□92
DSP + only planking at rice planting	1	60.02	60.02	57.00
DSP + bullock drawn ploughing twice for puddling	7	66.59 – 43.03	54.14	61.45
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	5	77.69 – 34.56	50.74	47.20
Upper Tail Reach (Village: Amwan)				
Deep Summer Ploughing (DSP) + tractor puddling	5	61.19 – 37.95	50.32	55.00
DSP + only planking at rice planting	2	59.90 – 54.70	57.30	65.00
DSP + bullock drawn ploughing twice for puddling	35	92.03 – 29.71	59.26	55.99
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	3	55.1□– 36.39	47.91	35.33
Lower Tail Reach (Village: Badauli)				
Deep Summer Ploughing (DSP) + tractor puddling	24	62.4□– 40.4□	49.90	37.60
DSP + only planking at rice planting	2	57.4□– 52.9□	55.23	3□20
DSP + bullock drawn ploughing twice for puddling	4	56.90 – 49.66	53.75	36.12
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	4	50.60 – 41.20	46.27	34.23

Table 6 b. Effect of tillage treatment on rice yield at various reaches in canal distributary (R.P. Channel –5) for the year 2002 (DSP during May 2002)

Tillage treatment	No. of Locations	Yield Range (q/ha)	Mean Yield (q/ha)
Upper Head Reach Village Ashpura			
DSP+Trac. Puddling + Planking	9	64.5-57.5	59.77
DSP + Only Planking	1	66.0	66.0
Conventional	2	55.5*52.0	53.75
Middle Reach (Village: Gopalpur)			
DSP+Trac. Puddling + Planking	13	67.5-53	61.5□
DSP + Only Planking	1	61.50	61.50
DSP + bullock pudling +Planking	1	57.50	57.50
Conventional	4	52-49.50	49.25
Upper Tail Reach (Village: Amwan)			
DSP+Trac. Puddling + Planking	3	62.0-65.0	63.33
DSP + bullock pudling +Planking	1	69.0	69.0
Conventional	3	50.0-60.0	55.0
Lower Tail Reach (Village: Badauli)			
DSP+Ploughing +Trac. Puddling + Planking	2	71.0-65.0	6□0
DSP+Trac. Puddling + Planking	2	77.5-60.0	6□5
DSP + Only Planking	1	67.5	67.5

3. 2 Effect of deep summer tillage on incidence of disease, insect-pests, nematodes, weeds and presence of predators/parasites in rice:

There were fewer incidences of insect pests in DSP fields than under non-DSP. Leaf folder was found in all conditions but its severity under DSP was less. Weed incidence under DSP fields was quite low than under non- DSP. Sheath blight disease incidence was comparatively severe in non-DSP than DSP fields**.** It was observed that diseases, insects, and weeds never crossed the threshold limit in DSP whereas non-DSP fields were infested badly (Table 4).

The weed load is much lower in DSP fields and reduction due to DSP over conventional tillage is 64.2□% and 62.5□% of weed number/m^2 and weed weight, respectively (Fig.4). Emergence of weed flora under DSP was also less at all the four sites (Table 5 a) and effect of DSP during 2002 is presented in Table 5b.

Nematodes growth was adversely affected under DSP in all command reaches. There was a reduction of 61.3 – 64 per cent of plant parasitic nematodes in DSP fields. Ploughing causes a decrease in the soil reflection coefficient.

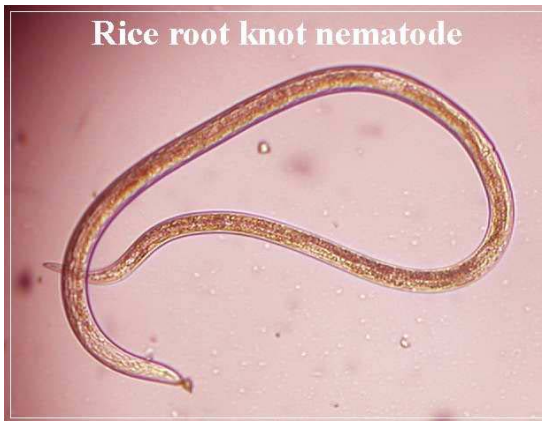

Plate. 5 : Nematode in roots of 35 days old rice crop

The presence of parasitic nematode in high number in rice field at RPC – 5 was established in the assessment under DFID Project. For effective management, a pilot study was conducted in RPC – 5 during 2003. The dialogue was made with SHG members and farmers in April, 2003 for initiating the assessment of nematode management in rice fields. The idea was broadcasted about solarization of nursery fields for healthy growth of seedling. Two farmers each in head, middle and tail reaches were willing to assess this technology. Total 06 farmers fields were chosen for this purpose. A transparent polythene sheet of 65 m^2 was provided to 06 farmers. In between 10 – 13 May, the fields were irrigated and polythene was set and air tightened. Four week after solarization the fields were open and rice seed was sown for nursery. At the same time in parallel field nematicide (Furadon 3-G) @ 3g/m^2 was used in 65m^2 area in order to compare the nematicide and solarization. The 3 kind of seedling were transplanted in main field and observation on grain yield was done. Farmer's response at the time of nursery, crop stage and harvest of rice was taken. In the assessment the parasitic nematode in Solarised nursery field were 500/liter soil, which were 750 in Furadon treated field and 2200 in control plot (John Bridge 2003). Solarization of nursery is useful in nematode management but economically very costly in farmer's opinion. Resource poor farmers may use the nematicide for nematode management.

This is mainly due to the removal of the insulating layer from the soil surface and exposure of darker, more energy absorbing soil (Khan, 19□□). The DSP soil warmed up more rapidly than non-DSP and reduced the growth of nematodes. Temperature of soil and the associative and antagonistic effect of soil also play an important role for the survival of microbes. Maximum microbial count was reported in spraying and lowest in summer and winter (Sarkar and Khan 2002 & 2003). Most of the micro-organisms prefer a temperature range of 25^0c and 35^0c (Khan *et al* 2003) whereas in DSP plots temperature rises upto 50^0c (Fig 3).

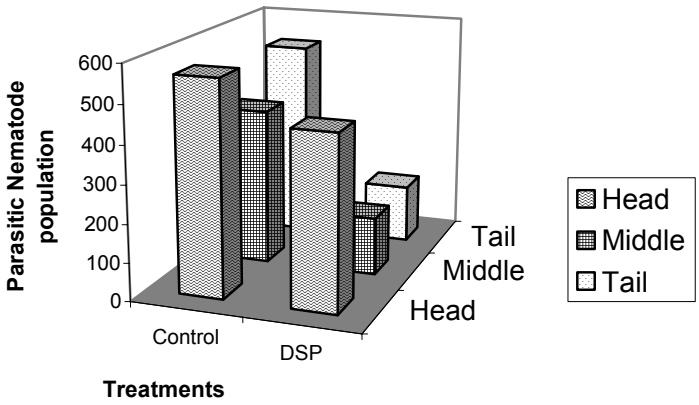

Fig.4 Effect of Deep summer ploughing on Nematode population under Rice -Wheat System in different reaches of RPC-5

Table 7. Incidence of Disease, Insect pest and weeds and presence of Predators/Parasite in rice fields

Incidence/ Presence	DSP	Non-DSP
	Nisarpura	
Disease	SB*, BLB, BLS	SB**, BLS, B, BrLS
Insect	LF, MB, HC, GH, GLH, GB, SB	GB, LF, GH*, GLH, WBPH
Predators/ Parasites	DF, S, LBB, DrF, PCF	DF, DrF, S, LBB
Weeds	T, M, FM, Ci, E	Ci, Fm**, Cr*, M, T
	Gopalpur	
Disease	BLB, BLS, SB*	SB**, BLB, B, BLS
Insect	LF*, BPH, WBPH, GB, MB	LF*, GH*, SL, BPH, GB, GLH, SB*
Predators/ Parasites	DF, S, F, WS, DrF, LBB, MGH, BA, X, W	DF, S, LBB, MGH, F, WS, DrF, W, X
Weeds	Ci, Cd, M, C, Fm	Fm**, Ci*, M, Cr, C, Cd
	Amwan	
Disease	SB*, BLS, Br LS	SB**, BLB, BrLS
Insect	LF*, GB, MB, SB	LF*, MB, WBPH, GB, SB, SL
Predators/ Parasites	DF, S, DrF, LBB, MGH, X, BA	DF, S, DrF, LBB, MGH, X
Weeds	T, M, Fm, E, Ci, C	FM**, Ci*, Cd, T, M, J, E
	Badauli	
Disease	SB*, B, BrLS, BLS	SB*, B, BLB, BrLS, BLS
Insect	LF**, BPH, MB, GB, H, GLH, K*	LF**, H, MB, BPH, CW, HC, SB, K*
Predators/ Parasites	DrF, DF, LBB, MGH, GB, S, C, MC, X, F, PCF, W	DrF, DF, MGH, GB, X, F, MC, W, LBB
Weeds	Ci, Fm, C, F*	Cr, Ci, Fm, C, E, Cd, T

Crossed threshold limit *in some fields * * in many fields

Abbreviations

1. **Disease:**
   SB- Sheath Blight, ***B***- Bleat, ***BrLS***- Brown Leaf streak, ***BLB***- Bacterial leaf blight, ***BLS***- Bacterial leaf streak
2. **Insect:**
   LF- Leaf folder, ***CW***- Case worm, ***BPH***- Brown plant hopper, ***MB***- Mealy bug, ***SB***- Stem Borer, ***H***- Hispa, *WBPH*- White backed plant hopper, ***GLH***- Green leafhopper, ***GH***- Grasshopper, ***GLH***- Green Leaf Hopper, ***K***- Kacchuiea, ***SL***- Semi Lopper, ***CW***- Case Worm, ***HC***- Horn Caterpillar, ***GB***- Gandhi Bug.
3. **Predators/ Parasites:**
   DF- Damsel Fly, ***F***- Fish, ***S***- Spider, ***W***- Wasp, ***PCF***- Pie pan culled fly, ***GB***- Ground Betel, WS- Water strider, ***C***- Cricket, ***DrF***- Dragon fly, ***MC***- Mole Cricket, ***LBB***- lady Bird Betel, ***MGH***- Meadow Grass Hopper, ***BA***- Black Ant, ***X***- Xanthopimla
4. **Weeds:-**
   Ci- *Cyprus irria,* M- *Mirchaiya*, ***Fm***- *Fimbristylis myliace,* ***T***- *Tikulie*,*Cynodan dactylon*, ***C***- *Cana Sp*., ***Cr***- *Cyprous rotandus*, ***E***- *Echinocloa sp.,* ***J***- *Jamhar*

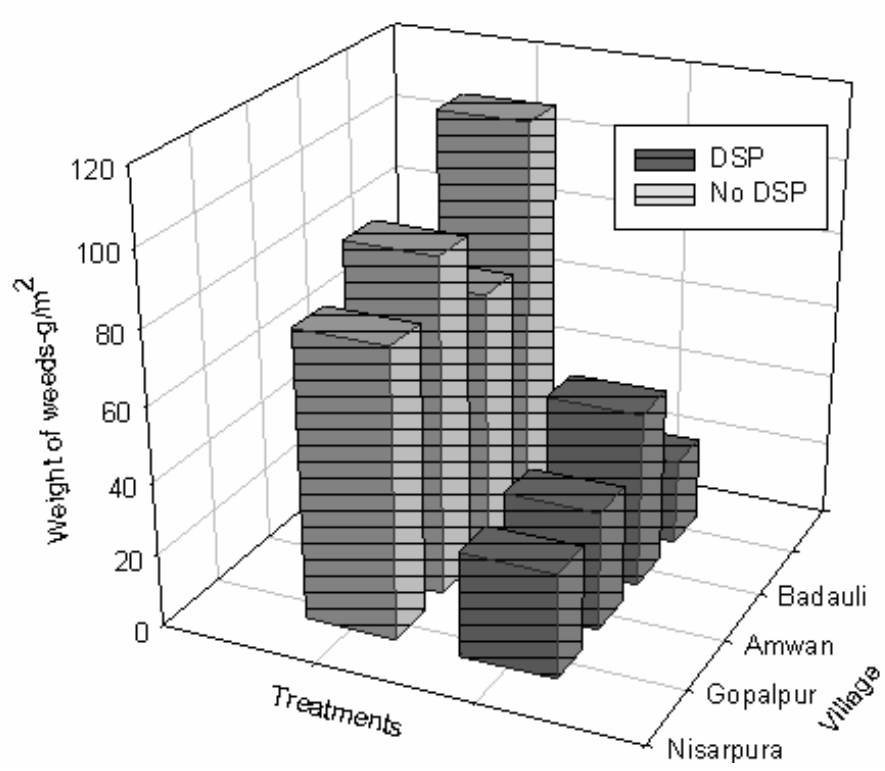

Fig. 5: Total weed growth in DSP and Non DSP rice plots before puddling

Reduction (%) due to DSP over conventional tillage: Weed number/m^2 - 64.2□
Weed weight - 62.5□

Table □a. Species of weed flora found under DSP and Non -DSP conditions

Village/Canal Reach	DSP	Non – DSP
Nisarpura/ Lower Head	Cynodon dactylon(Doob) Jhar rice (Dhan)	Cynodon dactylon Saccharum spp.(Garar)
Gopalpur/Middle	Echinochloa crusgalli (Sama) Cana Spp. ,Jhar rice	Cynodon dactylon Saccharum spp. Cyprus rotundus(Motha)
Amwan/ Upper tail	Cynodon dactylon Echinochloa crusgalli Cana Spp.	Saccharum spp. Cynodon dactylon
Badauli/Lower tail	Jhar Rice, Echinochloa crusgalli Cana Spp.	Cyprus rotundus Echinochloa crusgalli Cynodon dactylon Cana Spp.

* Emergence of perennial weeds was negligible under DSP but Jhar rice were seen.
* Under Non DSP *Cyprus rotundus* and *Saccharum sp*. were prominent weeds.

Table No. □b: Effect of DSP on weed emergence before puddling of rice field for the year 2002 (DSP during May 2002)

Village/canal reach	No. of weeds/m^2		Weed weight (g/m^2)	
	DSP	Non DSP	DSP	Non DSP
Aspura	23.00	100	17.7	114.0
Gopalpur	3□66	160	12.4	60.4
Amwan	33.00	200	1□6	124.1
Bedauli	27.□0	126	17.4	52.4
MEAN	30.16	146.5	16.5	□7.9

3. 3 Effect of DSP on winter crop

Deep summer ploughing has been found to increase the wheat, gram, and lentil yield in winter (rabi) season of during (2001 – 02 and 2002 –03) (Table 6 and 7). Zero tillage in wheat was found more effective for grain yield compared to conventional tillage without DSP. There was an early germination (3-4 days) under zero tillage over conventional practices. There was no drastic change in weed flora species emergence but the density was reduced to almost 50 per cent under zero tillage.

Plate.6: Effect of DSP on winter(wheat) crop.

Table 9. Effect of wet season tillage practices on winter crops yield after rice harvest in heavy soils of south Bihar, India (2001-02 & 2002 – 03)

Wet season tillage for rice establishment	Grain yield (t/ha)					
	Wheat		Gram		Lentil	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Deep Summer Ploughing (DSP) + tractor puddling	4.02 (23)	3.30 (29)	0.60 (3)	1.51 (3)	1.97 (2)	1.71 (6)
DSP + only planking at rice planting	4.05 (43)	2.71 (44)	0.45 (2)	1.01 (2)	1.13 (□)	1.41 (□)
DSP + bullock drawn ploughing twice for puddling	4.05 (5)	3.39 (15)	-	1.2 (5)	0.62 (2)	1.61 (11)
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	3.06 (12)	2.11 (20)	-	0.91 (7)	0.60 (4)	1.34 (□)

Numbers of field sites are in parentheses

The most problematic weed (*Phalaris minor*) density was reduced by about 50 per cent under zero tillage. The vigour of the wheat crop was found better under zero tillage (Table). It was probably due to early recession of irrigation water from the field and wheat crop remained green after first irrigation. Deep summer ploughing (DSP) helped to break the compact zone generally formed due to puddling (Khan *et al.,* 2002 b). Thus there was no yellowness of wheat crop after first irrigation, which normally happened under conventional tillage. There was saving of inputs of Rs.1340=00/ha under zero tillage over conventional tillage during winter season under tillage operation. Technology of deep summer ploughing is getting popular among the farmers of the Sone Canal Command of central Bihar due to higher yield, lower weed loads, and minimum incidences of disease, insect pest etc. It also improves the soil health and reduces the requirement of fertilizer and labour. Yield of wheat and lentil under different secondary tillage treatments are presented in Fig 5.

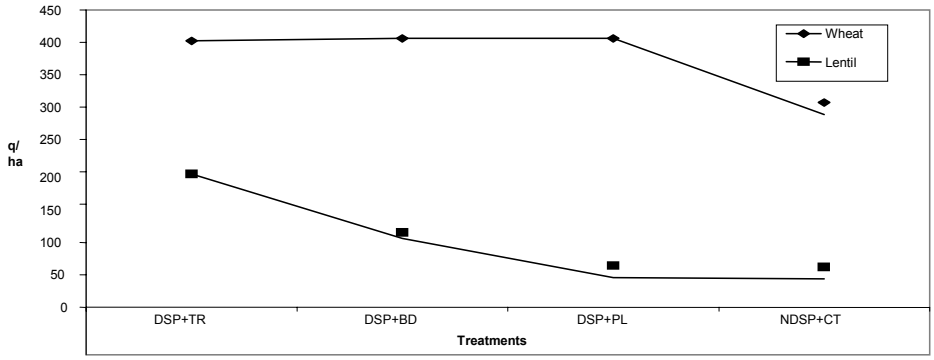

Table 10. Effect of tillage practices on wheat yield after rice under heavy soils of south Bihar India (2001-02)

Tillage for rice crop	Wheat yield (t/ha) at various winter tillage		
	Tractor planking	Conventional	Zero tillage
Deep Summer Ploughing (DSP) + tractor puddling	4.20 (9)	3.92 (12)	3.75 (2)
DSP + only planking at rice planting	4.33 (13)	3.91 (17)	3.96 (13)
DSP + bullock drawn ploughing twice for puddling	4.06 (2)	4.05 (3)	4.01 (3)
Non DSP + conventional tillage (bullock drawn ploughing 4-6 time) for puddling	3.05 (2)	2.90 ()	3.30 (2)

Numbers of field sites are in parentheses

Wheat germination time in days was significantly influenced by the zero tillage practice compared to conventional. Similarly number of weeds also reduced significantly (Table □).

Table 11. Effect of tillage practices on wheat germination, weed flora, water recession and crop vigour (2001-02)

Particulars	Zero tillage	Conventional tillage
1. Wheat germination (days)	7.31	11.04
2. Weed flora	Bathua, P.Minor, Akta Doob, saccharum, Wild pea	Batha,Doob,Lalgaria,Titulia , P.Minor, Wild pea, Akta
3. No. of Weeds/m^2	23.□	42.2
4. Vigour of the crop	1.0	0.□
5. Recession time of irrigation water from field (hrs).	3.02	5.92
6. Yellowness of wheat crop after irrigation	0.95	0.□6

Score: Crop Vigour: - Poor: 0, Good: 1, Very Good: 2, Yellowness (Y) – Yes: 0, No: 1

3.4 Response of the Stakeholders regarding DSP

There was fifty-three more farmers who practiced deep summer ploughing during 2002, out of which more than one third are progressive farmers and around 25 percent were sharecroppers (Table 12 to 14).

Table 12. Total number of farmers in deep tillage

	Share	Small	Progressive	Total
Head	04	04	03	11
Middle	02	0□	0□	1□
Tail	0□	0□	0□	24
Total	14	20	19	53

Table 13. First response about deep tillage

S.N.	First response about deep tillage	No. of farmers	Percentage
1.	Minimum no. of weeds in the field	53	100
2.	Insect and diseases were not effective on the crop	50	94
3.	Timely transplanting from deep tillage practice	46	□7
4.	Load on the bullock for preparation the land	3□	71

Tab 14. What measures can spread the large-scale adoption in the deep tillage?

S.N.	**What measures can spread the large-scale adoption in the deep tillage**	No. of farmers	Percentage
1.	Timely availability of tractor and disc plough in this area	53	100
2.	Extension of deep tillage technology in this area	47	□9
3.	To give knowledge about importance of deep tillage technology to the farmers in this area	44	□3
	What are the constraints for large scale adoption	No. of farmers	Percentage
1.	Lack of Massey Furgusion tractor, mouldboard and disc plough	4□	90.56
2.	Farmers don't knowledge about importance of the deep tillage in this area	20	37.35
3.	Small pieces of land	02	3.7
4.	Lack of own land	10	1□4

Table.15 : Specific response of farmers of deep tillage.

S.N.	Soil	No. of farmers	Percentage
1.	Soil no change	00	00
2.	Soil become friable and light	53	100
	Crop growth		
1.	Lower growth than conventional tillage	00	00
2.	Same growth as a conventional tillage	00	00
3.	Better growth than conventional tillage	53	100
	Crop yield (Middle + Tail)		
1.	Lower yield than conventional tillage	00	00
2.	Same yield as a conventional tillage	00	00
3.	Better yield than conventional tillage	42	100
	Saving of money		
1.	Lower saving than conventional tillage	00	00
2.	Same saving as a conventional tillage	00	00
3.	Better saving than conventional tillage	53	100

3.5 Farmers' opinion and feedback regarding DSP

3.5.1 Kharif: (wet season)

Monthly opinion of all □6 farmers who adopted DSP during May 2001was recorded during crop season. At DSP time 72% farmers were having positive opinion, which reduced to 57.0% at the time of rice transplanting, and negative opinion increased from 15.1 to 32.5%. Again at rice tillering stage the positive opinion increased to 64 per cent. The negative opinion was around nil at the time of rice harvest (Table 16). Highest value in negative opinion at

transplanting stage was due to difficulty in land preparation. Their opinion are presented in Fig. 6, 7 and in Tables 15 and 16.

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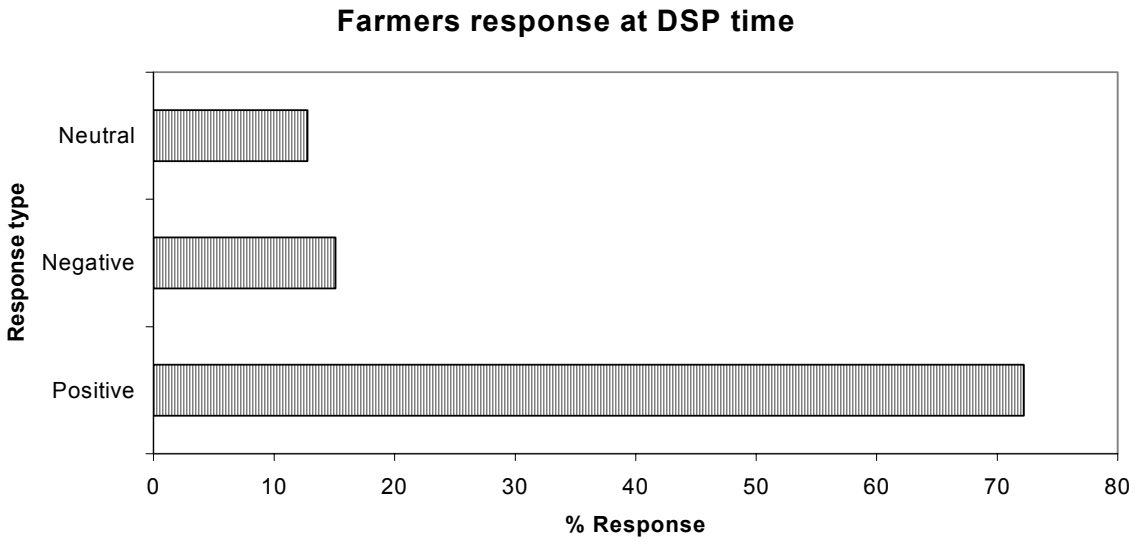
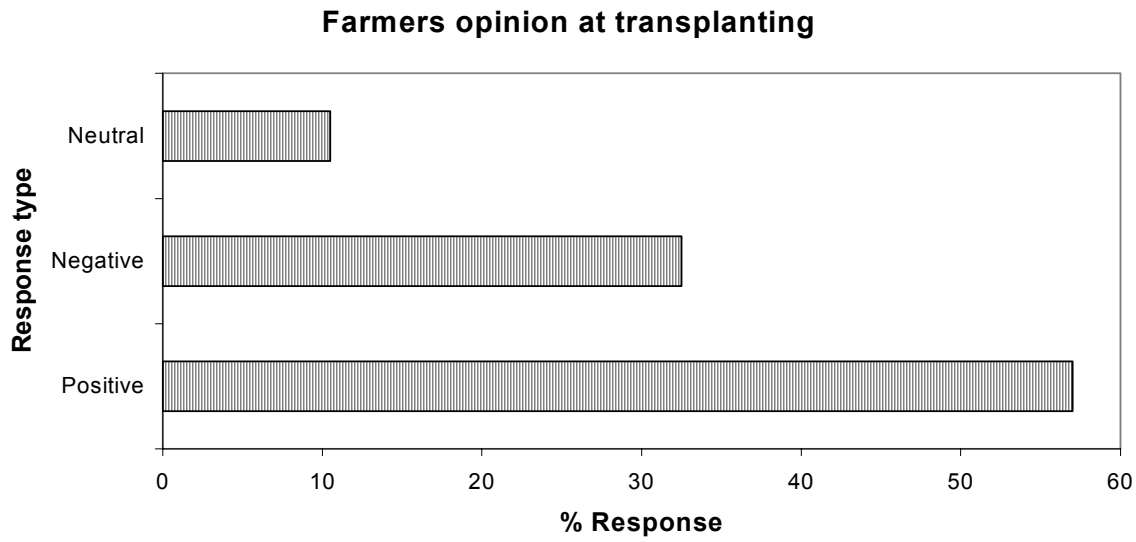




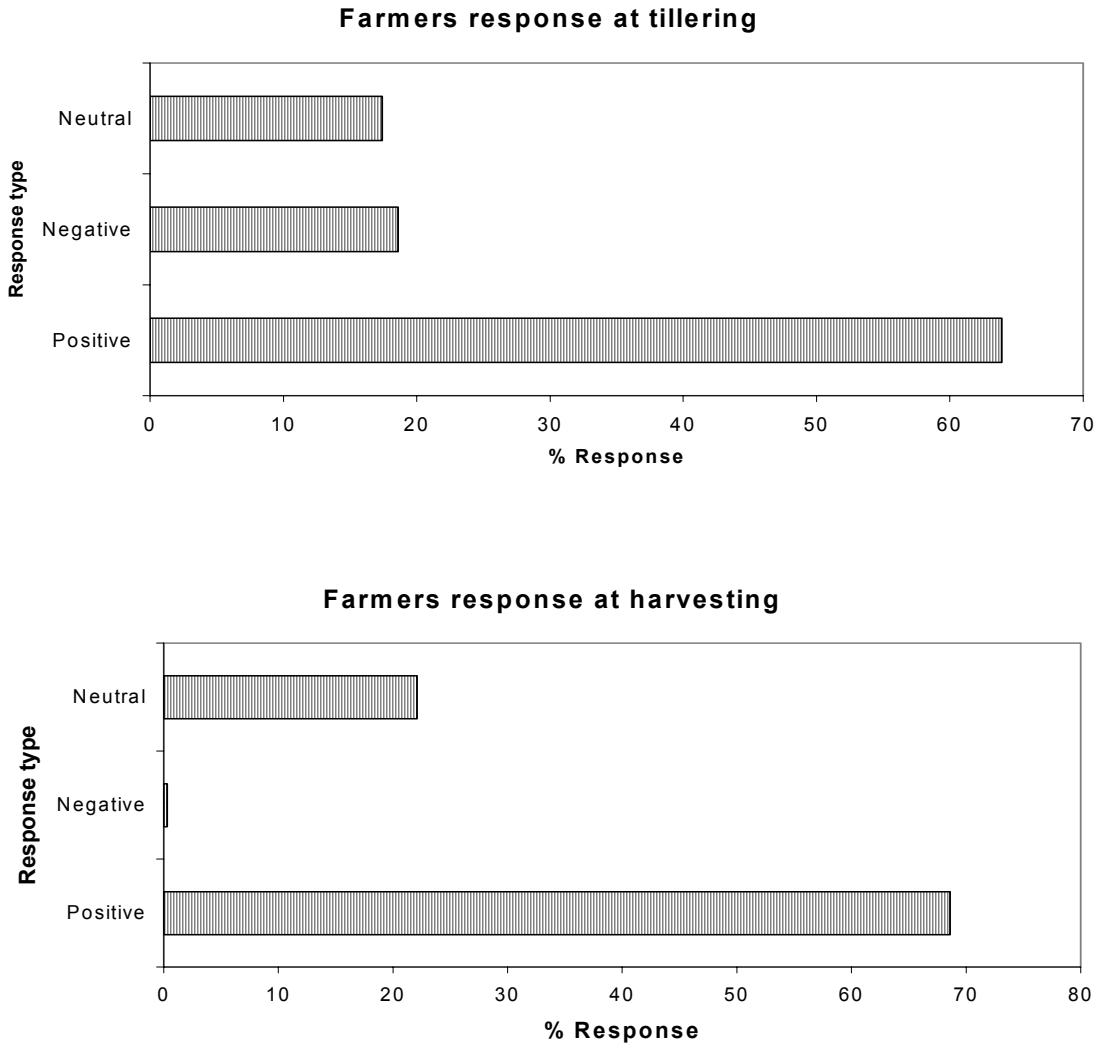
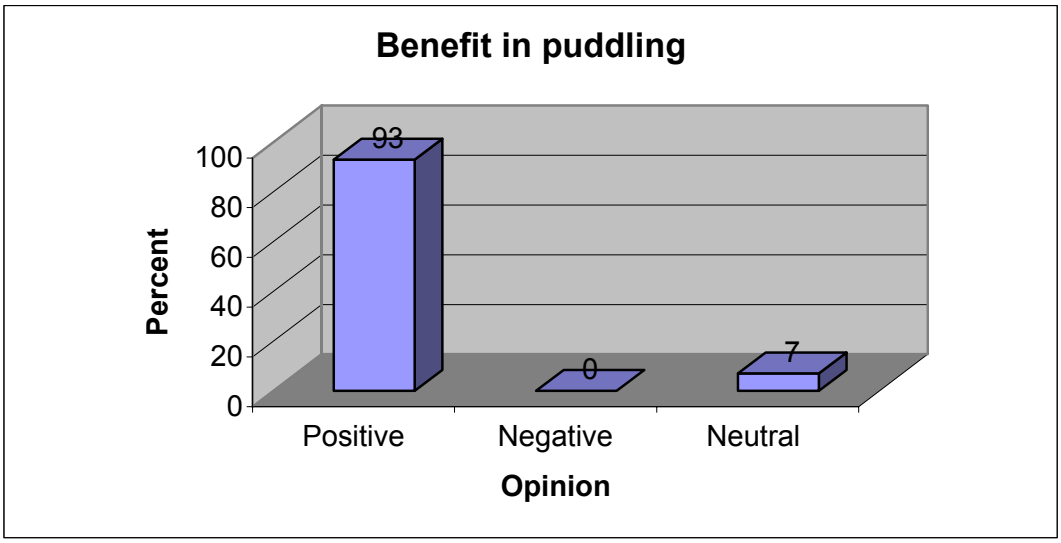


Fig. 7a. Farmers response about DSP (2001-02)



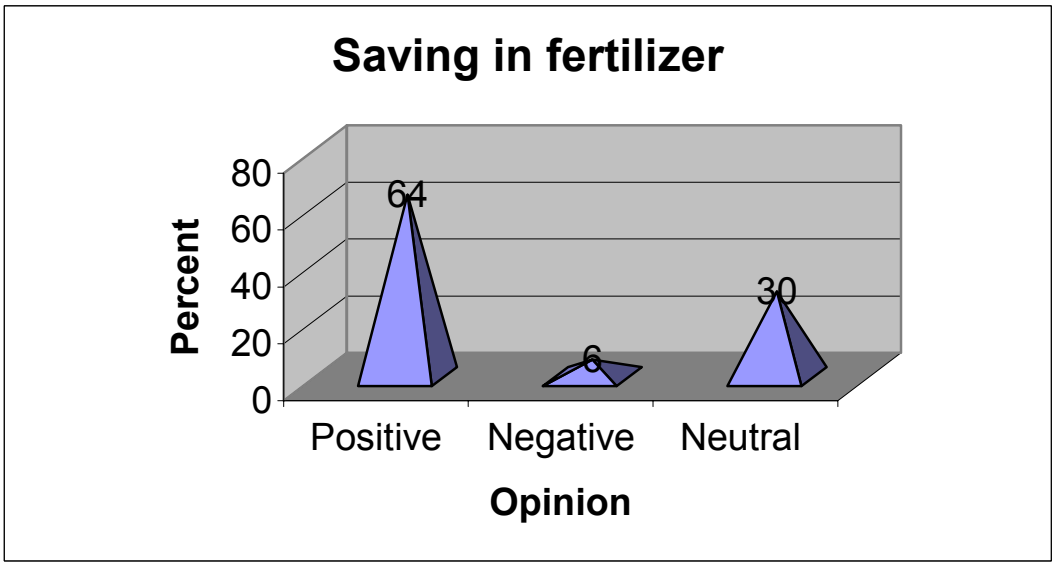
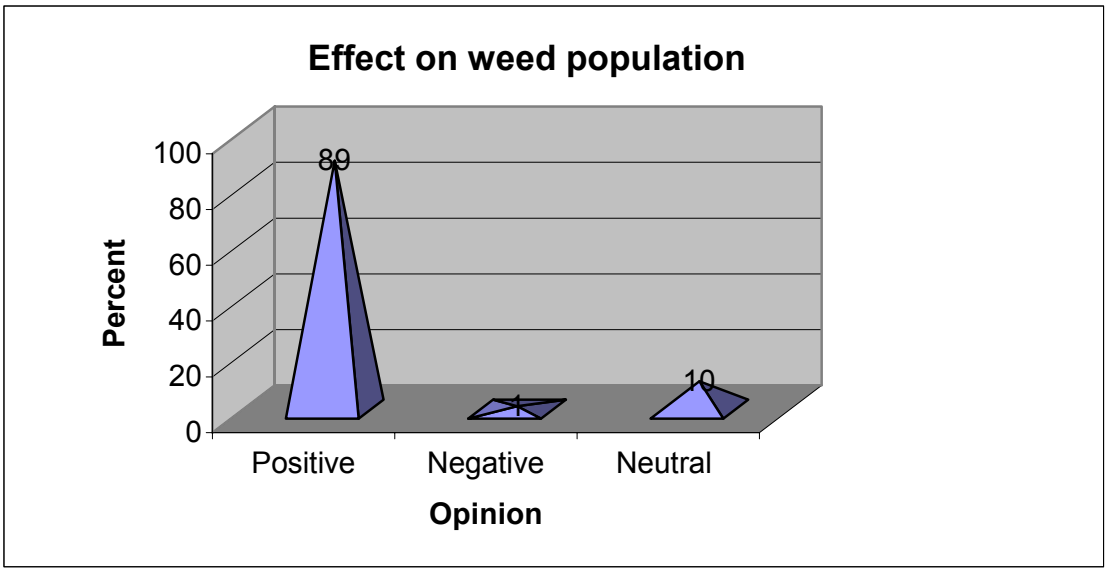


Fig. 7b. Farmers response about DSP (2003)



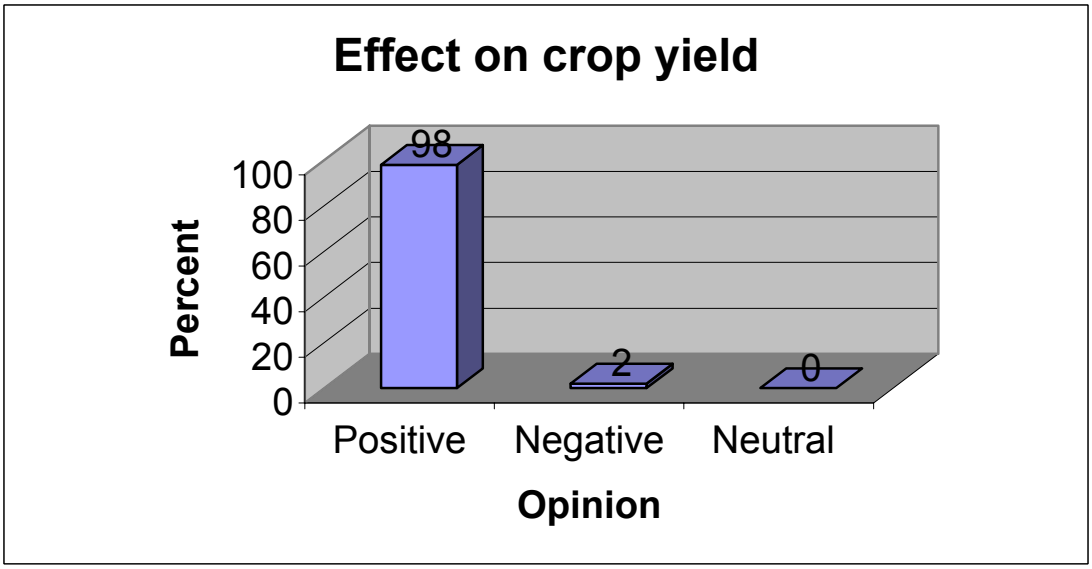
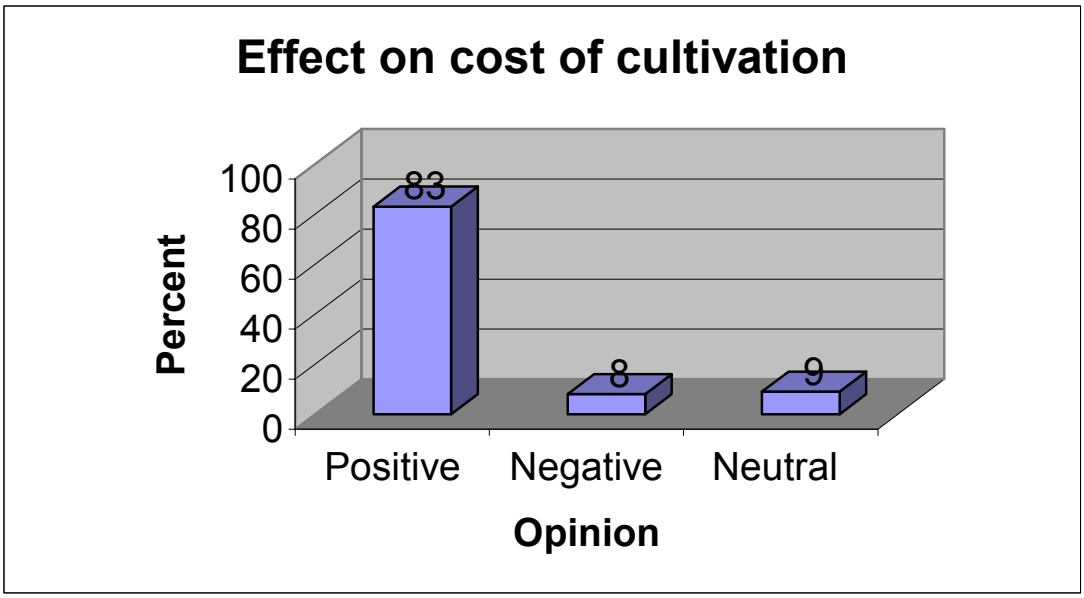


Fig. 7b. Farmers response about DSP (2003)



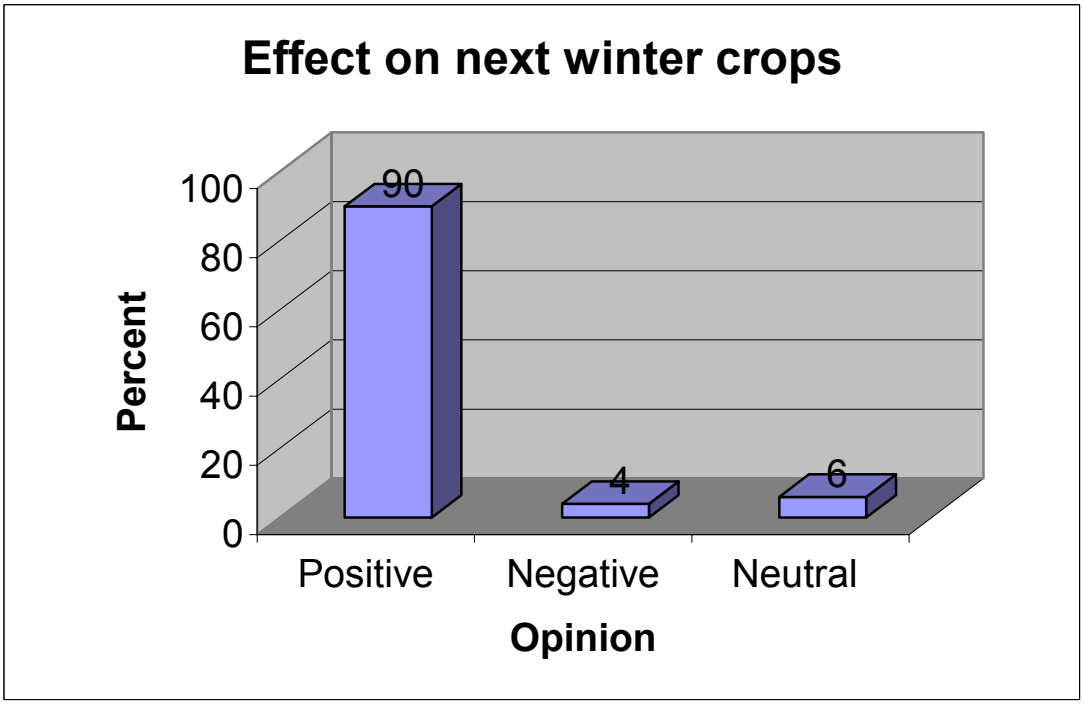


Fig. 7b. Farmers response about DSP (2003)

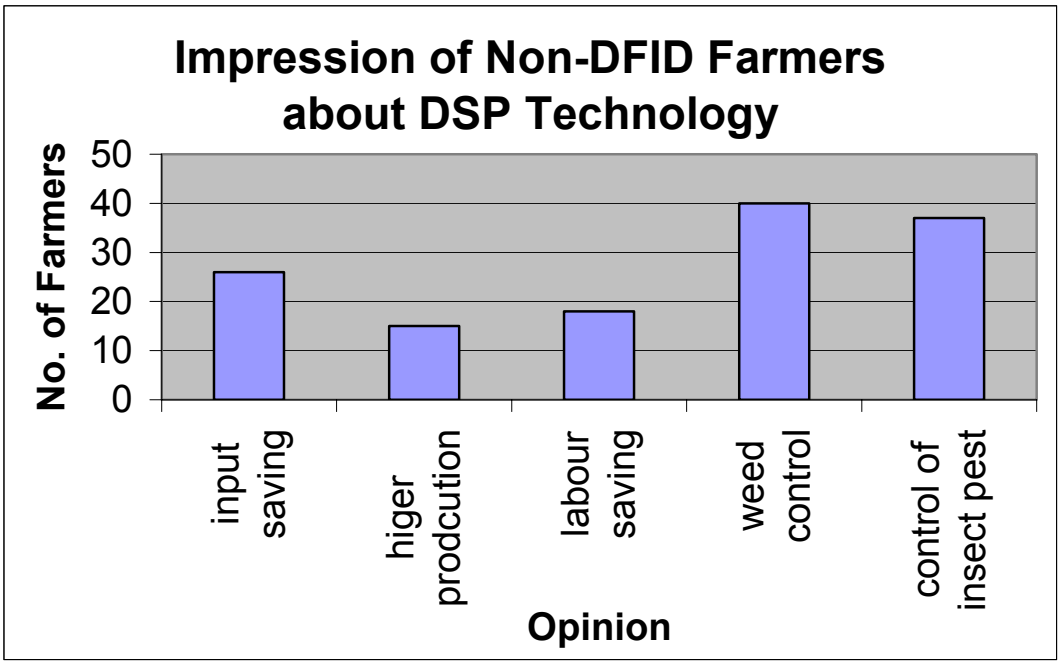


Fig.7b. Farmers response about DSP (2003)

3.6.1.1 Positive opinion

Soil became lighter in tillage operation and time taken in field preparation is less. Field preparation became easier because it required only 1 or 2 ploughing as compared to 4-6 ploughing under traditional tillage, so there was labour saving in rice transplanting. After DSP weed flora was changed. New weeds are less and have non-significant effect on rice crop. It reduced weed population in rice fields and so the cost of weeding. In anticipation of favourable effect less fertilizer was applied and even then higher good yield was obtained.

DSP destroyed winter weeds and problematic perennial weeds like, *Cynodon dactylon* and insect's eggs. Incidence of diseases is less. Field remains pulverized for a long time after removal of water from the field. Irrigation water remains in the field for longer duration and crop is comparatively greener. In DSP fields during dry spell the cracking was delayed by one week as compare to non-DSP fields. Rice plant population is uniform and healthy. First irrigation takes more water but later less water is needed in DSP field.

Tillering in rice crop is better and yield is comparatively high. Rice can be sown with the onset of monsoon because it takes less time in field preparation and rain water can be fully utilized, whereas transplanting in non DSP fields are delayed for a month or so in most cases.

3.□1.2 Negative opinion

Field became undulated and preparation became difficult with bullock because it requires higher draft. DSP fields need more water for puddling. Non-DSP peripheral side lands become slippery during puddling. It is not good for small plots because more draft is required for bullocks for frequent turning in such fields.

3.□1.3 Suggestions:

Deep summer ploughing should be done just after harvest of wheat crop as at that time the available soil moisture, helps in easy drafting. There should be facility of field levelling. Deep ploughing should be done in cris cross manner. Some other deep ploughing implements may be used which can also cover peripheral side lands that are left by the disc.

3.□2 Rabi/Winter season:

Table 16. Farmers' opinion about effect of Deep Summer Ploughing on winter crop in RPC-5, Bihar, India (2001-02)

Village	Total no. of farmers	Crop stage	No. of farmers		
			Positive	Negative	Neutral
Nisarpura	16	Tillering	□ (50.0)	6 (37.5)	2 (12.5)
		Harvest	9 (56.3)	3 (1□□)	4 (25.0)
Gopalpur	16	Tillering	12 (75.0)	4 (25.0)	0 (00.0)
		Harvest	12 (75.0)	1 (6.3)	3 (1□□)
Amwan	2□	Tillering	22 (7□6)	2 (7.2)	4 (14.3)
		Harvest	22 (7□6)	3 (10.7)	3 (10.7)
Badauli	26	Tillering	10 (3□5)	□ (30.□)	□ (30.□)
		Harvest	16 (61.6)	5 (19.2)	5 (19.2)

Figures in parentheses represent percentage of farmers interviewed

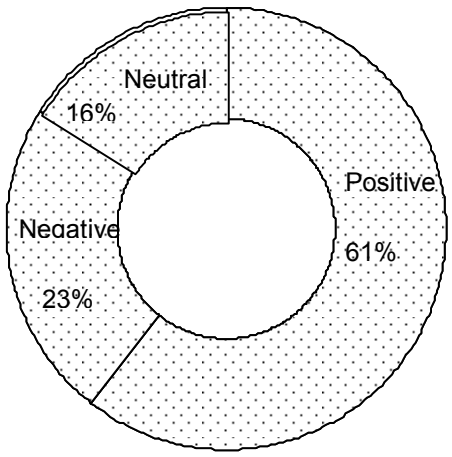
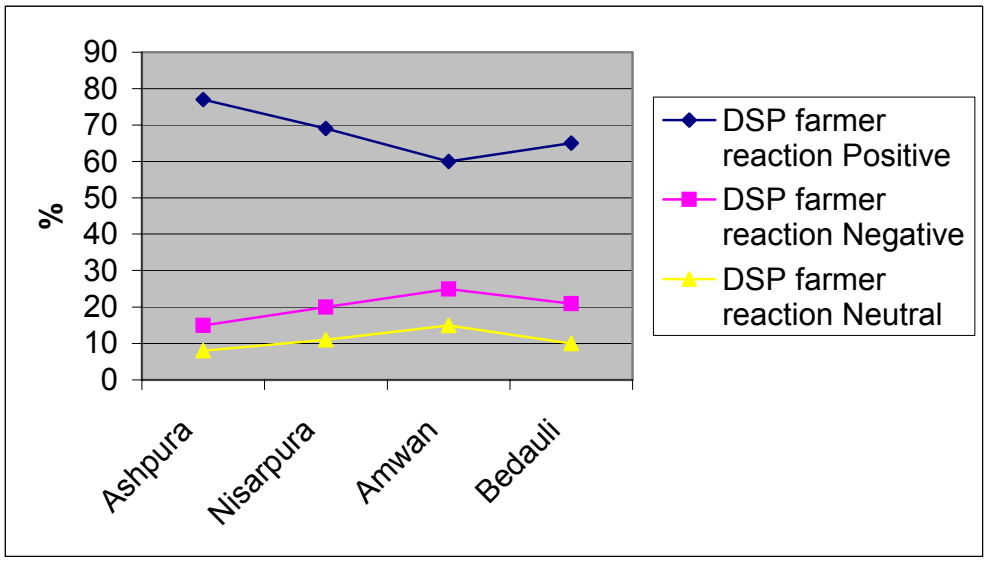


Fig. □ Farmer's response on DSP during winter crop 2001 - 02

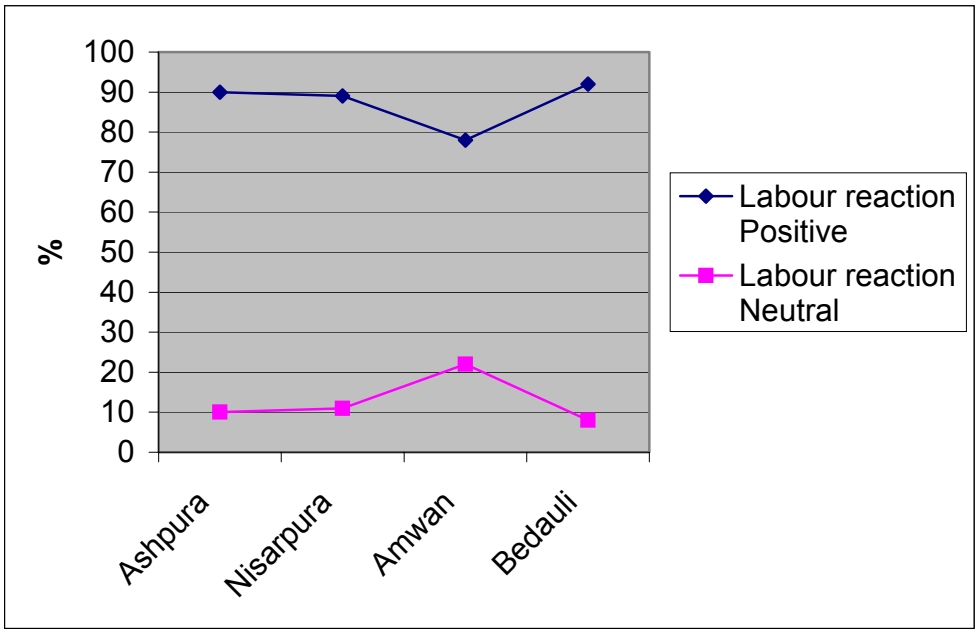
By May 2002 there were no farmers against DSP and there was drastic change of attitude from reluctance to partial agreement and finally on self paid tillage operations (Table 16).

Table 17. Farmers choice for DSP on payment basis observed for 3 years summarized

Farmers' choice	No. of farmers		
	2001	2002	2003
Ready for DSP with full payment	00	96	210
Ready for DSP with partial payment	24	1□5	3□0
Ready for DSP on free basis	52	300	67□
Not ready for DSP even on free	15	00	00



A) DSP farmers' reaction



B) Labour reaction

Fig. 9. Farmers reaction on deep summer ploughing during wet season 2002

3.7 Adoption

3.7.1 Adoption by new farmers**:**

The farmers in RPC-5 and adjoining locality are aware about the benefit of DSP. Due to farmer-to-farmer communication, the technology spread has been observed from 4 villages in 2001 to 1 villages in 2003. The number of farmers who adopted this technology were 224 in three years. In 2003, total 590 farmers showed their willingness to adopt DSP on payment basis.

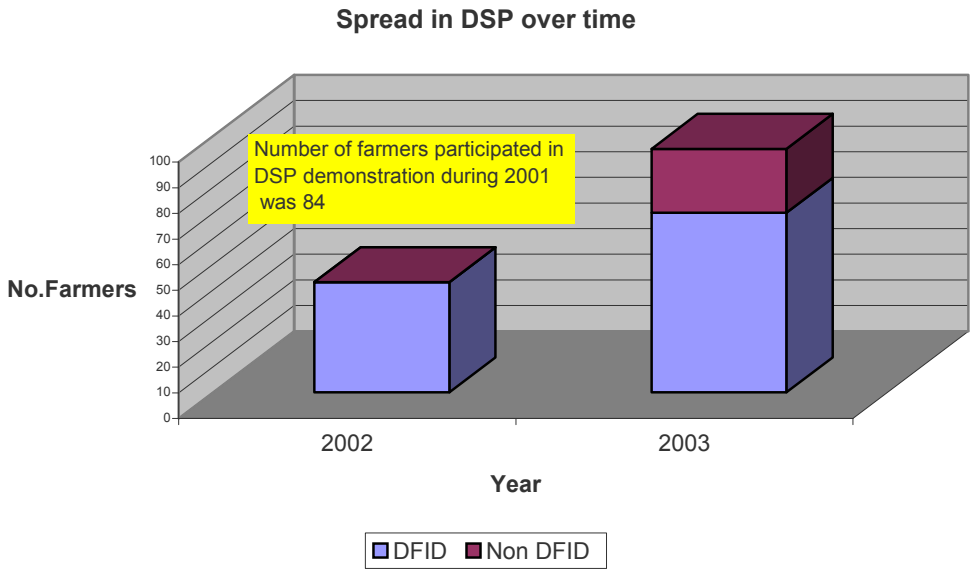


Fig.10: Spread of deep summer ploughing technology in RPC-5 canal command (Bihar)

3.7.2 Emergence of service provider

Assessing the increased market demand, one service provider (tractor owner) Sri Madhurendra Kumar Arya of Badipur of Majholi canal distributary, a non-DFID project villager decided to provide service to the locality.

Plate Interaction with a service provider

3. Livelihood improvement

The practice of deep summer ploughing (DSP) appeared to have improved the livelihood of farmers as result of the following

i. There was lower cost of operation under land preparation, transplanting, weeding and PIM measures in DSP over other conventional methods.
ii. Incidence of diseases and insect pest was lower than critical level in DSP fields reducing the cost on herbicides.
iii. Weed growth was drastically reduced thereby reducing the manual labour for weeding and use of weedicides.
iv. Nematode growth was reduced upto 71 per cent and loss in yield was checked.
v. Additional income was achieved due to higher yield of wet season rice and winter crops.
vi. Participatory budgeting was done and Rs. 1950/bigha (Rs. 7 00/ha) was additional income to the DSP farmers.
vii. Due to ease in transplanting, labour could cover more area in one day and received more remuneration. In this region, labour gets a part of crop in remuneration at harvest. As more yield was obtained in DSP plots, they earned more.
viii. There are conventional ways of cultivation in this region. The resource poor farmers could not adopt mechanized farming. DSP provides opportunities to SHG volunteers to go for renting the implements and suitable tractor couplings and increase their income.

3.9 Effect of DSP on Environment:

Weed, insect-pest and diseases in crops damage the yield and agriculturists are compelled to control it through chemical herbicides. The intensive use of weedicides and pesticides raised a serious concern about its effect on crop, soil, ground water, and environment. Heavy doses or overuse of herbicides to save the high yielding crops are increasing water pollution, contamination of food grains and food articles with toxic residue and causing other environmental hazards. It was observed by the farmers that disease, insect – pest and weeds were successfully controlled through the use of DSP and they rarely used herbicide for such control.

3.10 Communication

Different communication materials with relevant topics were prepared based on different communication mechanisms and road maps intended to various target groups like farmers with tractors/without tractors, SHG's, sharecroppers, and landless, tractor owners, banks and service providers. Leaflets, brochures in local language about the methodology, benefits, and success stories were distributed among the stakeholders. Farmers' exposure visits and field days etc were organized.

Farmers to farmers communication meeting held for technology dissemination and scaling up:

Plate. 9&10: Experience sharing among farming community regarding DSP

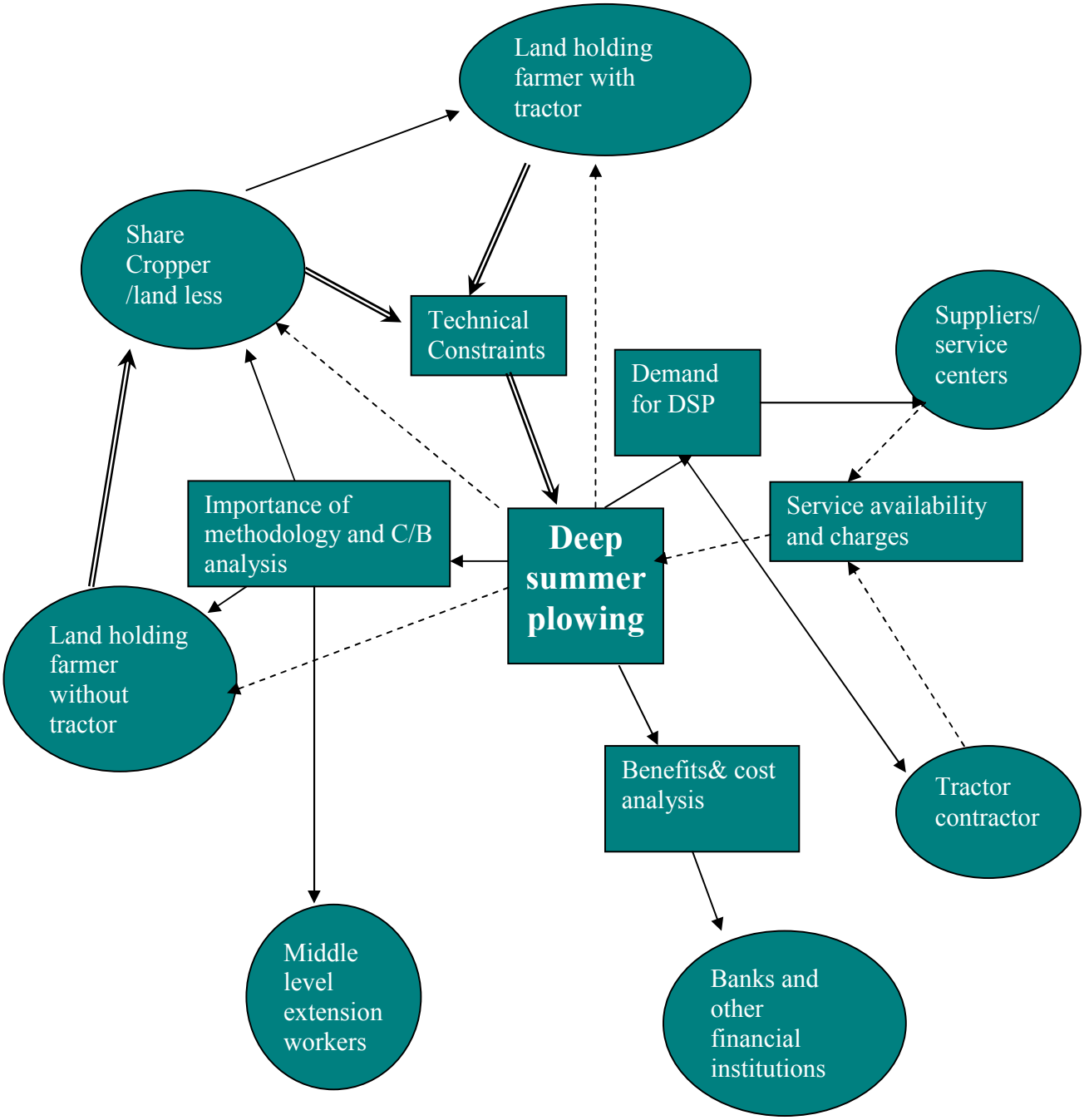


Fig.11: Communication strategy for deep summer ploughing

4.0 Conclusions

4.1 Experiences and lessons learnt:

This approach to stimulate participatory research led to a wide range of innovation and experimentation around the key ideas or technologies related to tillage practices that were broadcast.

Focusing on social development, provision of relevant information and the involvement and development of local professional providing service delivery led to a change in the role of scientists and other technical experts in the projects. Rather than leading or initiating interventions they began to operate as resource in consultancy mode acting in response to an expression of demand from an interested group.

4.2 Salient achievements:

Service provider at village level had emerged for DSP. The DSP was adopted without any project support in around 117.00 ha in adjoining project area in 2004.Behavioral change in adoption was observed. After the harvest of winter crops in May, 2002, farmers dropped their reservation about DSP and there was change in their attitude from reluctance to partial agreement and later they were ready for tillage operations on self-payment.

4.3 Scaling up:

Up scaling can be achieved through broadcasting of communication material on DSP among service providers, farmers, SHGs and NGOs and also by sensitization of tractor owners, service providers and extension agencies about the benefits, market demand and income potential.

Demonstrations of DSP in rice fallow fields during mid March to mid April to realize its beneficial effect in rice crop and spread of success story through farmer-to-farmer communication, organization of field days and electronic demonstrations will also help in scaling up of the technology.

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Land preparation for rice planting

Rice field Scenario on 2 nd August, 2001 in *Gopalpur*

Plate.2:

DSP fallowed by direct seeded rice (*50 days old crop*)

Plate.3

Plate.4: Root system of 110 days old rice crop

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