INTERNATIONAL JOURNAL OF ENGINEERING AND MANAGEMENT SCIENCES

www.scienceandnature.org

POTENTIAL OF WATER MANAGEMENT TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE IN INDIA: EVIDENCES FROM FARMER'S PARTICIPATORY ACTION RESEARCH

[1] Shiv Kumar, [2] Dabas J.P.S., [1]Sandeep Kumar and [3]Kanika

[1]Senior Scientist and Research Associate, National Centre for Agricultural Economics and Policy Research, New Delhi-110012

[2]Principal Scientist, CATAT

[3]Senior Scientist, NRCPB, Pusa, New Delhi-110012

ABSTRACT

The farmer's participatory action research program for demonstrating the usefulness of five water conservation technologies for sustainable agricultural productivity are successful taken up in three agro-ecologically different operational areas. In semi-arid areas, aqua-ferti-seed drill made possible sowing of Rabi crops in the situation of deficit sufficient conserved soil moisture because application of aqueous fertilizer at root zone depth at time of sowing. In Indo-gangetic plain, raised bed technology convinced farmers in saving irrigation water, energy and time along with a higher crop yield and easy inter-culture crop operations. Intercrop of sugarcane in standing wheat crop could establish a sugarcane crop with 60-70 days advanced date of sowing. Orobanchae weed is a major problem in mustard crop and termite in almost all crops in Rajasthan. Utility of biogas slurry is an impetus for introduction of biogas technology and enhanced agricultural productivity through improved organic content and water holding capacity of soil along with improvement in soil health. Competition among their roots and shoots for light, air, nutrients and moisture becomes anti-tillering. SRI has reversed it. Smooth and even surface of the soil created by laser leveling encourages crop germination, improved crop stand, saving water (22%), time, cost saving and energy and finally improving yield and production mainly due to uniform moisture and nutrient distribution pattern. It is suggested that some private parties i.e entrepreneurs should become active for laser leveling of farmers' fields in the operational areas on custom hiring basis at commercial rates. Appropriate capacity building for participatory farmers was done with intent of enhancing adaptive capacity, and compliance ability for collective group performance and also to treat water as an 'economic good'. They interact with each other and mutually share the advantages of these technologies with the help of information and communication technologies. This experiential learning and sharing about innovative use of these technologies would keep on playing pivotal role in improving, refining and strengthening these experiences for further spread of these technologies. Such action research program in participatory mode gives birth to a movement of saving water through use of technologies for sustainable agriculture and harvest more from each drop of water applied.

KEYWORDS: Technology, Water, Management, Technologies, Sustainable Agriculture.

INTRODUCTION

The productivity enhancement through judicious use of water in field crops has recently been a great concern to agricultural researchers and policy makers. Water, most precious natural resource on the planet earth, is a critical input for all production systems, be at crops or livestock. Ground water in different parts of the country has been over exploited resulting in sharp decline in groundwater level (GOI, 2006). The press reports beamed on June 5, 2009, 'A year into new Act, water table up, power bills down' (Kaur, 2009). The availability of water for agricultural sector is bound to decrease also due to fierce competition from industrial, power and domestic use in urban areas. Moreover, unscientific management of available water resources has drastically reduced the availability of water resources in India (Hira et.al 2004). The varied agro-climatic situations and settings have unique difficulties and problems in water management and require different appropriate technologies to manage sustainable use of water. A few improved water management technologies (viz. Aqua-ferti-seed drill, Raised bed planter, System of Rice Intensification (SRI), Laser leveling, and biogas slurry) evolved by different scientific organizations and institutes have shown potential to contribute significantly in enhancing the agricultural productivity per unit of land and per drop of water. For example, in arid and semiarid areas devoid of irrigation facility, farmers generally use surface irrigation method for pres-sowing irrigation to ensure good germination and better crop stand. Only a part of this water is utilized by crop and a major part of it goes as waste in the form of evaporation and deep percolation, which also takes away soluble plant nutrients from fertile soil.

Large numbers of farmers in semi-arid and arid areas are unable to sow their crops in the absence of sufficient soil moisture and even if they sow, the germination of the crop remains poor (Sidhu et.al. 2007). To reduce this unwarranted loss of water used for pre-sowing irrigation and to ensure good crop stand in such areas, Aqua-ferti-seed technology has emerged as one of the water saving technologies. Likewise, Biogas slurry offers to be a potential source to enhance the organic contents of the soil to increase its water and nutrient holding capacity in areas where organic carbon content in soil is less. The raised bed technology and System of Rice Intensification (SRI) enhanced productivity of field crops generating synergy among water, crops, agronomic practices, soil nutrients, crop varieties and implements etc. In addition to it, the total depth of water applied per irrigation is greatly influenced by the quality of land leveling. Laser leveler does precision land leveling for efficient and judicious use of irrigation water in crops wherever surface irrigation techniques are used (Karam Singh 2011). All these technologies have multiple potential benefits to farmers in three ways: (i), to increase income of farmers through improved water and nutrient use efficiency and increased crop yields, (ii), the farmers gain through reduced cost of cultivation in terms of fuels, water, agro-chemicals and fertilizer savings, and lastly, (iii), the improved soil structure and fertility will be additional advantages and reduced use of agro-chemicals and chemical fertilizers. However, despite these potential benefits, the technologies have not been used by farmers on a large scale. Policy makers, researchers and farmers advocate that all such technologies, which save water, must be promoted (PSFC, 2009). With this background, it becomes essential to carry out the specific objectives: firstly, to assess and transfer the water management technologies to the end users; secondly, to study technical feasibility, socio-economic viability and environmental impact of the water management technologies; thirdly, to enhance water and nutrient use efficiency for improved soil-health and sustainable agricultural productivity; and fourthly, to strengthen farmers capacity regarding various water management technologies. The knowledge emanating from this action research would help farmers joined their hands to work in tandem and learn from one other's experiences, researchers will keep on playing pivotal role in improving, refining and strengthening these experiences for further spread of these technologies. The ripple effect of technologies will move from farmer to farmer, village to village, district to district and finally state to state all simultaneously will generate movement of saving water through use of technologies and harvest more from each drop of water applied.

MATERIALS AND METHODS:

The demonstration of potential benefits of the technology-investment options like raised bed planter, aqua-ferti-seed drill, laser leveler, etc. from the perspective of savings in water and other benefits is needed. Three operational areas with different agro-ecological conditions i.e Upper Gangetic plains (irrigated) in villages viz Kekpur, Siriyal, Chak, Jahangirpur and Jawa of Buland Shahar district of UP; Trans-Gangetic plains (limited irrigation) in villages Chhej Pahadipur, Malikpur and Majra Dubaldhan of district Jhajjar of Haryana; and Western Dry region (rainfed) in villages Ureeka, Pipli, Jharora, Tirpali badi and Gudan of districts Jhunjhunu and Churu of Rajasthan. Farmer's clubs, self help group were formed in each of the villages and participating farmers, for layout of demonstrations, were identified through these groups. Necessary implements/ machinery and other critical inputs like high yielding variety seeds were provided to farmers through these self help group. A total of 180 ha demonstrations during four cropping seasons (Kharif 2008 to Rabi 2009-10) comprising of 13 ha on Aqua-Ferti Seed-drill in Wheat, Mustard, Chickpea and Barley in Jhunjhnu and Churu districts of Rajasthan, 23 ha on Raised Bed Planting in Bulandshahar district of U.P. and Jhajjar district of Haryana, 78 ha on use Bio Gas Slurry in Paddy, Bajara, Pigeoonpea, Moong, Wheat, Mustard, Chickpea, Barley, Onion and Methi in all the three operational areas, 19 ha on SRI is district Bulandshar, and 47 ha on Laser Leveling in Paddy, Wheat, Sorgum, Pigeopea, Barley and Mustard in Bulandshahar and Jhajjar areas. Synergistic advantages of combination of two such technologies together in the same field (Laser Leveler, Bed Planter; Biogas slurry, Bed Planter and Laser Leveler, Biogas slurry) were also demonstrated to the farmers in Bunadshar. Each demonstration was laid in an area of 1 acre to avoid disadvantages of small plot demonstration. For each demonstration, two plots of same area were selected, one for demonstration of technology with recommended packages and practices and other as control plot with the package of practices in vogue in the area. The water applied and saving in water application due to intervention of technologies was determined accordingly for different demonstrations. Besides this, more than 40 farmers training programmes, six farmer's group visits from operational areas, and 20 crop field days each involving more than 40 farmers / farm women were organized to educate the farmers about all water management technologies in form of awareness campaign.

RESULTS AND DISCUSSION:

To educate the farmers regarding the economic value of water and to improve water use efficiency, capacity building of the farmers is crucial (Kumar *et.al.* 2007). Thirteen field demonstrations of Aqua-ferti-seed drill technology in Churu and Jhunjhunu districts of Rajasthan during 2008-09 and 2009-10 to demonstrate potential benefits of the technology in terms of enhanced yield and income per drop of water. The demonstrations were of 1 acre size (the standard land units popular in the operational areas). All the demonstrations were laid down in participatory mode with active participation of the farmers based on ideas and insights underlying field problems in a better way and also for better layout of the experiments.

In response to save the groundwater from "diminishing to the point at which farmers and residents of the region are forced to react", (Rodell et al., 2009) and state like Punjab has enacted legislation like Punjab preservation of sub-soil water Act, 2009 (Karam Singh 2011). On the same patter, Haryana also responded by enacting its own legislation. These are significant land marks for necessitating improvements in water use efficiency, through techniques like laser leveling of field, aqua-ferti-seed drill, biogas slurry etc, which not only save moisture, organic matter and also enhances yield and income of farmers.

During the crops period, with the use of aqua-ferti-seed drill the beneficiary farmers could on an average save around 22 percent of irrigation i.e equivalent to the required pre-sowing irrigation which was equivalent to

385 m^2 per hectare. The saving in irrigation cost was Rs. 1800 per hectare which comes around 17 percent of irrigation cost. The maximum was in gram and mustard. Besides this, the participating farmers also reported that the germination of the crop was uniform and better in demonstration plots as compared to control plots. In comparison to control plots, the demonstration plots recorded on an average increase of around 12% in yield realizing additional income of Rs. 1800-2000/- ha which was equivalent to 7 percent of total income. The maximum was in gram and wheat. The maximum was observed in gram and wheat. There was saving in electrical energy as there was 20 hours, saving in irrigation time which was translated in 25 percent saving in electrical energy. The major role of aqua ferti seed drill was saving irrigation water required for pre-sowing irrigation. It also helped both reducing number of irrigation as the moisture provided at the time of sowing in root zone depth could sustain crop longer and weed infestation was much lower in demonstration plot in comparison to control as reported by beneficiary farmers. [Table 1]

Twenty three field demonstrations of Raised Bed technology in Bulandshar and Jhajjar districts during 2008-09 and 2009-10. This technology has saved each on an average around 37 percent of irrigation water and time required per irrigation. Although the number of irrigations were same in demonstration and control plots (5 irrigation each). Overall in five irrigations, 20 hours of irrigation time was saved leading to proportional saving of water and electricity power required to pump it. An extra yield of around 11 percent i.e 6 q/ha equivalent to extra income of Rs. 8055/ha was realized by the farmers along with saving of (38 %) 163 kWh energy /ha in demonstration plot. The technology made easy feasible movement of labour in field for removal of weeds and other cultural operations etc. The time saving in irrigations was utilized for other necessary works. The beneficiary farmers felt that there was no need of physical intervention in conveying water in different parts of the field as flow of water was smooth. [Table 2]

Environmentalists have appreciated slurry manure as well as biogas technology as a whole. When fresh cow dung dries, approximately 30 to 50 per cent of the nitrogen escapes within 10 days. While nitrogen escaping from digested slurry within the same period amounts to only 10 to 15 percent besides the high value of slurry as fertilizer because 30 to 40 per cent of organic carbon present in the dung is decomposed as carbon dioxide and methane (Paul et al., 1996). The performance of a biogas plant is dependent on the local conditions in terms of climate, soil conditions, the substrate for digestion and building material availability. The design must respond to these conditions. The potential of technology in varying agro-climatic situations and in many different crops on various parameters differ significantly. Hence overall average picture as per season wise and location wise performance of 78 ha demonstration on use of Bio Gas Slurry in different crops is presented in [Table 3]. Demonstration plot farmers applied only 4 irrigations against 5 irrigations in the control plot. Thus farmers saved 20 percent water consequently saving of about 35 per cent of total time for irrigation. This water saving was due to increase in water holding capacity of the soil through incorporation of biogas slurry in the soil. Farmers got 14 percent higher grain yield in the demonstration plot than the control plot. Similarly farmers also got higher fodder yield. In semi arid area, a thin layer was formed by slurry on the soil surface, which acted as mulch. This layer not only saved water but also suppressed the weed germination. The crop in the demonstration plot was healthier, free from weed infestation, and the numbers of effective tillers were nine to fourteen in demonstration plot as against five to ten in control plot. This may be due to cumulative effect of better availability of nutrient in balanced form through biogas slurry and efficient use of water. If the same is seen in monetary terms farmers got Rs 7800 /ha of total income. They saved Rs.2600/ha on irrigation cost due to efficient water use and also saved fertilizer/ manure cost (25%) which is equivalent to Rs 756/ha. Besides this, beneficiary farmers were able to save 14 percent of energy which could be used for other alternatives. Thus the technology was liked not only by the demonstration farmers but also by other farmers who saw the difference in performance of demonstration plot and control plot. Farmers reported not only luster and shine of grain was better but also better rice recovery from the paddy produced in demonstration plot.

One of the major concerns often voiced is the increase in area under rice under flood irrigation method, the major water-consuming crop (Parihar et at., 1993). Intervention in the form of SRI in rice belt is one of the options to save irrigation water, besides many potential benefits. The success of SRI is based on the synergetic development of both the tillers and second root system. With vigorous root and their better access to the nutrients and water, the overall vegetative development of the crop is enhanced resulting in more photosynthesis. Thus the overall health of the crop is improved and plants are more resistant to attack of pests and diseases. Moreover, the number of effective tillers per plant is increased with full size development of grains in the spikes. Water management system in rice plays a significant role and may attain the status from zero to hero under SRI (Singh and Sajla, 2002).

A total of 25 demonstration of one acre each during Kharif 2008 and 23 demonstrations of one acre each during Kharif were laid out. Grain yields were higher under SRI compared to traditional planting (control) of rice. The higher yields under SRI was attributed to higher number of effective tillers, longer ear head, more weight of ear heads, more number of grains per ear head and low insect, disease and weed infestation as compared to control. In addition to difference in yields between SRI and traditional planting (6.37%), there was considerable saving of inputs equally especially irrigation water (33%), energy use and irrigation cost and quantity of seed (40%). Though fertilizer/manure cost saving under SRI is not visible but total income and yield increase equivalent to 6 percent was reported. The irrigation water in SRI demonstrations was applied as per need of the crop and crop was not kept continuously flooded with water which resulted in significant reduction of methane emission (Byrnes, et. al 1995). The use of weedicides and pesticides was very less in SRI thus the technology besides being economical is also eco-friendly. Besides these, farmers of study area reported that the technology is good but raising of nursery and transplanting of tender seedlings (10-12 days) require more care and are more labour consuming. Maintenance of thin layer of water on the soil surface for successful of SRI was not possible in undulating/uneven fields and in case of heavy rainfall it is really difficult to drain out the water especially when the sub surface in surrounding areas is saturated. Despite all these, we inferred that, though the difference in yields between SRI and traditional planting might be less but the water, seed and energy requirements were significantly less under SRI. [Table 4]

The precise laser- land leveling and proper proper plot size increase the irrigation efficiency at afield scale, which saves 25-30 per cent of irrigation water application (Sidhu et al., 2007). The season wise and location wise performance of 47 ha demonstration of laser leveling in different crops i.e 16 ha wheat, 16 ha paddy, 7 ha pigeon pea and 8 ha mustard are presented in Table 5. The uniformly leveled field facilitated average saving (17%) of irrigations across crops. Almost 31 % saving in total irrigation water and same level of saving in irrigation time was observed. Approximately 15% increase in yield and income from demonstration plots was also observed. The saving in irrigation time also led to saving in energy to the tune of 30%. This saving in time was due to easy and uniform flow of irrigation water leading to better water distribution efficiency. Farmers were very much satisfied with the saving of time primarily because the power supply is errant and they do not get continuous supply of electricity for irrigation. As a consequence of frequent power cut a farmer is not able to cover his fields in one go of irrigation. They have to face power cut when part of the field is irrigated. When power supply resumed irrigation process starts afresh taking lot of time. With the application of laser leveler technology, the spread of water is fast and uniform in the field. This led to saving in irrigation cost by more than 20 %. This time saving led to water, energy and cost saving with the use of the technology. The total return from demonstration was 15% more than that of control plot. Overall, laser leveler helped saving precious resources like time, energy and water along with improved nutrient use efficiency. [Table 5]

CONCLUSION

The farmer's participatory action research program for demonstrating the usefulness of five water conservation technologies for sustainable agricultural productivity was successful taken up in three agro-ecologically different operational areas. In semi-arid areas, aqua-ferti-seed drill made possible sowing of Rabi crops in the situation of deficit sufficient conserved soil moisture because application of aqueous fertilizer at root zone depth at time of sowing would enhance germination, better growth and higher yield. In Indo-gangetic plain, performance of raised bed technology convinced the participatory farmers in saving irrigation water, energy and time along with a higher crop yield and easy inter-culture crop operations. Intercrop of sugarcane in standing wheat crop with the help of raised bed technology could establish a sugarcane crop with 60-70 days advanced date of sowing and also along with saving of irrigations and field preparation without any adverse effect on wheat crop yield. Such identified ancillary advantage of the technology is going to play a significant role in further spread of the technology in this area. In semi arid region, symptoms of nutritional deficiency are observed in almost all crops in sandy soils which has low water holding capacity and lacks organic matter. Orobanchae weed is a major problem in mustard cropin Rajasthan areas. Termite is a serious problem in almost all crops, largely due to use of undecompsed farm yard manures. Utility of biogas slurry in such environment shows the necessity and importance of introduction of biogas technology. The technical knowhow of maintenance of biogas plant and uses of biogas slurry was imparted to participatory farmers by conducted on site training programs. Biogas slurry continuously coming out of plant has shown potential of enhancing agricultural productivity of the area through improved organic content and water holding capacity of soil along with improvement in physical, chemical and biological parameters of soil health. Moreover weed seed present in dung were destroyed during anaerobic digestion and slurry is almost free from weeds.

The success of SRI is based on the synergetic development of both the tillers and second root system. This is possible when the competition for light, air and nutrients is minimum among the crop plants as they get enough space for their development. The participatory farmers saved inputs particularly water without adverse effect on yield and income on leveled field with adequate drainage facilities in case excessive rainfall. The grain yields were higher (6.37%), remarkable saving of inputs especially irrigation water (33.86 %), quantity of seed (4.7%), use of energy requirement (33.84 %) under SRI compared to traditional planting of rice. This might be due adherence to SRI principles especially when crop is not kept continuously flooded with water under SRI except a maintenance of a thin layer of water 2 to 3 cm depth uniformly for 10 days for proper establishment of seedlings. Technology is good but more labour with soft skill is required for raising of nursery and transplanting of tender seedlings. It is suggested that SRI has power to remove the wrong notion among farmers that they can boost their paddy yields by planting paddy plants (35-45 days) more densely in a clump at closer spacing in zigzag manner. Competition among their roots and shoots for light, air, nutrients and moisture becomes anti-tillering.

Smooth and even surface of the soil created by laser leveling encourages crop germination, improved crop stand, saving water (22%), time, cost saving and energy and finally improving yield and production mainly due to uniform moisture and nutrient distribution pattern. Saving in time was due to easy and uniform flow of irrigation water leading to better distribution efficiency. Farmers were highly impressed with an engineering intervention technology in natural resource conservation. It has saved equally (around 69 percent) of total time in irrigation, total irrigation water and irrigation cost. Also, the energy use for irrigation saved is around 60 percent. It is suggested that some private parties i.e entrepreneurs should become active for laser leveling of farmers' fields in the operational areas on custom hiring basis at commercial rates.

Appropriate capacity building for participatory farmers was done with intent of enhancing adaptive capacity, and compliance ability for collective group performance and also to treat water as an 'economic good'. Participatory farmers of different operational areas in three states were socialized among themselves by field visits and trainings. They interact with each other and mutually share the advantages of these technologies with the help of information and communication technologies. This experiential learning and sharing about innovative use of these technologies would keep on playing pivotal role in improving, refining and strengthening these experiences for further spread of these technologies. Such action research program in participatory mode gives birth to a movement of saving water through use of technologies for sustainable agriculture and harvest more from each drop of water applied. The support of the local non-government organizations in social mobilization can be availed as it is a challenging task to mobilize farmers to adopt to new and innovative method/system of water management through collective action of farmers.

REFERENCES

B H Byrnes, E R Austin, B K Tays (1995) Methane emissions from flooded rice soils and plants under controlled conditions. Soil Biology and Biochemistry Volume: 27, Issue: 3, Pages: 331-339

GOI, (2006) Dynamic Ground Water Resources of India (as on March, 2004), Ministry of Water Resources, CGWB (Central Ground Water Board), New Delhi

Hira, G.S., S.K. Jalota and V.K. Arora (2004) Efficient Management of Water Resources for Sustainable cropping Pattern in Punjab, Bulletin, Department of Soils, Punjab Agricultural Univesity, Ludhiana

Kaur, Sukhdeep (2009 A Year Into New Act, Water Table Up, Power Bills Down, Indian Express, June 5.

Kumar, Shiv; Devender; Chakarvarti, K; Chand, P. and Dabas, JPS (2007) Mode of Operation and Performance of Contract Farming of Cottonseed in Haryana, Agricultural Economics Research Review, 20(1): 99-116.

Parihar,S.S., S.D. Khepar, Raghbir Singh, S.S. Grewal and S.K. Sondhi (1993) Water Resources of Punjab. A Critical Concern for the Future of Its Agriculture, Bulletin, Department of Soils, Punjab Agricultural University, Ludhiana

Paul Jun, Michael Gibbs, and Kathryn Gaffney (1996) CH4 and N2O Emissions from Livestock Manure, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines), pp. 321-346.

PSFC (2009July 2005 to July 2009) Addressing the Farmers Problems, September

Rodell, Mathew, Isabella Velicogna and James S Famiglietti (2009) Satellite-based estimates of groundwater depletion in India. Nature08238/doi:10.1038 (posted on NASA website)", The online version is available at www.nature.com/nature.

Sidhu, H.S., Manpreet Singh and S. S. Ahuja (2007) Level Fields to Increase Irrigation Efficiency, Progressive Farming, Punjab Agricultural University, Vol. 38, No. 1, Pp. 9-12.

Singh, Karam (2011) Groundwater Depletion in Punjab: Measurement and Countering Strategies, Vol. 66, No. 4 (October-December) pp. 573-589.

Singh, Karam and Sajla, Kalra (2002) Rice Production in Punjab: Systems, Varietal Diversity, Growth and Sustainability, Economic and Political Weekly, Vol. 37, No. 30, July 27, pp.3139-3148.

[Tables]
Table 1 Performance of Aqua-Ferti Seed Drill

Location - Jhunjhunu and Chhru (R.J)

Variables	Jhunjhunu and Churu (Saving %)	Jhunjhunu and Churu	Churu	Jhunjhunu and Churu	Jhunjhunu	Average
	Barley 2008	Wheat 2008	Gram 2008	Wheat 2009	Mustard 2009	Saving (%)
No. of Irrigation	20	11	33	--	25	22.25
Time per Irrigation(h)	--	--	--	--	--	--
Total time of irrigation (h)	20	11	33	12	25	20.2
Total irrigation water(m3)	20	11	33.3	17	25	21.26
Irrigation cost Rs/ha	20	11	18.22	12.5	25	17.34
Fertilizer /Manure cost Rs/ha	--	--	0.00	7.73	--	7.73
Yield q/ha	7.15	10.41	25.78	11.54	6	12.18
Total Income Rs/ha	7.15	10.41	20.13	6.12	6	9.96
Energy (kWh/ha)	20	11	33	12.5	25	20.3
IWP (l/kg)	25.34	19	47	15.96	29.16	27.29

Product Price @ Rs-1080/q (Grain), @ Rs-150/q (Straw)

Table 2 Performance of Bed Planter Technology

Location - Buland Shahar (UP) and Jhajjar (HR)

No. of Irrigation	Buland Shahar (Saving %)	Jhajjar	Buland Shahar	Jhajjar	Jhajjar	Average
	Wheat 2008	Wheat 2008	Wheat 2009	Wheat 2009	Onion 2009	Saving (%)
Time per Irrigation(h)	41.67	50	37.4	31.25	20	36.064
Total time of irrigation (h)	41.67	50	34.4	42.7	20	37.754
Total irrigation water(m3)	41.66	50	34.4	42.7	20	37.752
Irrigation cost Rs/ha	-41.45	50	46.87	42.7	20	23.624
Fertilizer /Manure cost Rs/ha	-16.31	-16.31	0.37	6.32	--	-6.4825
Yield q/ha	14.44	4	23.31	9.9	5.5	11.43
Total Income Rs/ha	14.53	4	23.58	14.29	3.2	11.92
Total Variable Cost Rs/ha	-14.5	11.5	--	--	--	-1.5
Net return Rs/ha	47.37	21	--	--	--	34.185
Energy (kWh/ha)	41.67	50	34.4	42.7	20	37.754
IWP (I/kg)	61.65	52	46.75	47.86	22.4	46.132

Note: Product Price @ Rs-1080/q (Grain), @ Rs-150/q (Straw) for wheat

Table 3 Performance of Bio Gas Slurry demonstrations

Location - Jhunjhunu and Chhru (RJ), Buland Shahar (UP) and Jhajjar (HR)

	Jhun jhunu and Churu (Saving %)	Buland Shahar	Buland Shahar	Jhun jhunu and Churu	Jhun jhunu and Churu	Jhun jhunu and Churu	Jhun jhunu and Churu	Jhun jhunu and Churu	Buland Shahar	Jhun jhunu and Churu	Jhun jhunu and Churu	Jhajjar	Jhajjar	Jhun jhunu	Jhun jhunu	Jhajjar	Buland Shahar	Average
	Bajra 2008	Paddy 2008	Wheat 2008	Wheat 2008	Barley 2008	Onion 2008	Mustard 2009	Methi 2008	Paddy 2009	Bajra 2009	Moong 2009	Paddy 2009	Pigeon pea 2009	Wheat 2009	Gram 2009	Wheat 2009	Wheat 2009	Saving (%)
No. of Irrigation	20	16.67	--	28.5	20	22.2	25	20	9	25	25	11.11	--	11	25		25	20.25
Time per Irrigation(h)	11	15	22.58	--	--	--	--	--	28.57	10	--	--	33.33	5		31.2	25	20.19
Total time of irrigation, h	29	30.83	23	28.57	20	22.2	25	20	35.06	32.5	25	11.11	33.33	15.34	25	31.2	31.25	25.79
Total irrigation water(m3)	29	30.83	22.58	28.6	20	22.22	25	25	35.06	32.5	25	11.11	33.33	15.34	25	31.25	31.25	26.06
Irrigation cost Rs/ha	28.8	30.83	22.58	28.6	25	22.22	25	20	35.06	32.5	25	11.11	33.33	15.34	25	31.25	31.25	26.05
Fertilizer / Manure cost Rs/ha	--	29	-38.92	37.1	65	46.93	26.32	50	38.98	93.75	--	40.98	95	43.72	90.2	-44.94	75	43.21
Yield q/ha	15	6.34	9.14	15.48	14.41	12.07	23.08	17.78	6.65	18.14	7	8.91	22.73	12.85	41.5	23.69	37.59	17.20
Total Income Rs/ha	16	6.34	9.14	15.48	14.41	12.07	23.08	17.78	7.23	15.94	7	13.19	8.98	12.92	34.73	24.97	37.59	16.29
Energy (kWh/ha)	28.8	29.2	22.58	28.57	20	22.2	25	20	35.06	32.5	25	11.11	33.33	15.35	25	39.56	42.8	26.83
IWP (I/kg)	39.7	35	29	38.14	30	30.59	39	32.07	39.11	42.86	29.68	18.4	45.69	25	46.99	44.18	50.05	36.20

Table 4 Performance of SRI demonstrations

Location - Buland Shahar (UP)

Variables	Buland Shahar (Saving %)	Buland Shahar	Average
	Paddy 2008	Paddy 2009	Saving (%)
No. of Irrigation	16.67	9.09	12.88
Time per Irrigation(h)	18.75	8.33	13.54
Total time of irrigation (h)	32.29	16.67	24.48
Total irrigation water(m3)	32.29	16.67	24.48
Irrigation cost Rs/ha	32.29	16.67	24.48
Fertilizer /Manure cost Rs/ha	-2.4	1.26	-0.57
Yield q/ha	5.04	8.62	6.83
Total Income Rs/ha	5.04	8.69	6.865
Energy (kWh/ha)	32.29	16.67	24.48
IWP (I/kg)	35.44	23.28	29.36

Table 5 Performance of Laser-leveller Technology

Location - Buland Shahar (UP) and Jhajjar (HR)

Variables	Buland Shahar (Saving %)	Buland Shahar	Buland Shahar	Jhajjar	Jhajjar	Buland Shahar	Jhajjar	Jhajjar	Average
	Paddy 2008	Wheat 2008	Paddy 2009	Paddy 2009	Pigeon pea 2009	Wheat 2009	Wheat 2009	Mustar d 2009	Saving (%)
No. of Irrigation	15.38	20.00	--	11.11	--	--	12.36	25.00	16.77
Time per Irrigation (h)	28.14	27.78	14.29	16.67	28.57	31.25	29.33	4.80	22.60
Total time of irrigation (h)	39.19	42.23	14.29	25.93	28.57	31.25	35.00	28.60	30.63
Total irrigation water(m3)	39.19	42.20	21.04	25.93	28.57	31.25	36.00	28.60	31.60
Irrigation cost Rs/ha	37.73	-42.23	16.66	25.93	28.57	30.04	38.63	30.00	20.67
Fertilizer /Manure cost Rs/ha	2.53	--	12.89	--	--	--	8.10	-53.58	-7.52
Yield q/ha	10.91	10.61	11.53	10.40	19.36	23.58	17.10	18.64	15.27
Total Income Rs/ha	10.91	10.61	11.49	10.27	18.92	23.53	17.02	19.37	15.27
Total Variable Cost Rs/ha	--	-2.84	--	--	--	--	--	--	-2.84
Net return Rs/ha	--	20.37	--	--	--	--	--	--	20.37
Energy (kWh/ha)	39.19	42.26	14.28	25.30	28.57	30.00	36.00	17.66	29.16
IWP (I/kg)	45.10	47.74	23.15	32.92	40.15	44.36	45.33	39.80	39.82

Note: Product Price Wheat @ Rs-1080/q (Grain), @ Rs-150/q (Straw)
Product Price Paddy @ Rs-2300/q (Grain), @ Rs-80/q (Straw)