Water saving practices in rice-based cropping systems in Indian Scenario as a Research

Tirjyak Kumar Das, Bibhu Santosh Behera, L.M.Garnayak

Abstract— **Water is a Precious source of Life. Now days Conservation of Agriculture follows the Water Saving Practices. As Rice is a Hydrophytes plant, it requires water. But now a day's SRI Method of Paddy Cultivation helps to conserve water. Here the Researchers Prove the illustration of Water Saving Practices in Rice-Based Cropping System as India is the origin of Rice and follows the Agrarian Policy hence be justified.**

Index Terms— **Water, Conservation Agriculture, Participatory, Development, Hydrophyte, SRI, Puddling, RCT**

I. INTRODUCTION

Water is a limited and scarce resource, though two-third of the world is covered by water. There is a water crisis everywhere, but the crisis is not about having too little of water to satisfy our needs. It is a crisis of managing water so badly that millions of people and environment suffer badly.Providing universal access to the basic minimum water need of 50 litres/day/people worldwide by 2015 would take less than 1% of the amount of water we use today. India ranks 133rd among 180 countries in terms of water availability, 120th in 122 countries in terms of water quality and 1st among the top 10 ground water abstracting countries. The per capita availability of water has declined from 5177 m^3/year in 1951 to 1820 m^3 in 2001 and will further decline to 1341 m^3 in 2025 and 1144 m^3 in 2051. Already 5.5% area and 7.6% population in our country suffers from absolute scarcity of water (<500m^3/caput/year). About 85% of fresh water is used for agriculturein India. There is urgent need for efficient management of water for agriculture in the country as it consumes the lion's share of fresh water and there is declining trend in availability of water for agricultural use from 85 to 74 % because of industrialization, urbanization and modernization.On the other hand, Irrigated area has to increase to 140-150 million ha to produce 450-500mt food grains to feed 162 crore people by 2050.Development of irrigation is costly and has many environmental repurcations in the era of rapid climate change.The efficiency of canal irrigation system is only 40%, which is to be increased to 60% and for ground water from 60% to 75%. It is estimated that a 10% increase in irrigation water use efficiency can bring 40% water availability for other uses.

Manuscript received Dec 06, 2014

Tirjyak Kumar Das, P.G.Scholar,Dept. of Agronomy,College of Agriculture,Bhubaneswar, India

Bibhu Santosh Behera, Ph.D Research Scholar,Dept. of Extension Education,OUAT,Bhubaneswar, India

L.M.Garnayak, Chief Agronomist, AICRP on IFS,OUAT,Bhubaneswar, India

Water productivity refers to the value of goods and services produced per unit of water consumed.Basically, in agriculture it refers to more food per drop of water in physical terms and more rupeesper drop of water in economic term.In agriculture,water productivity can be increased through developing options and tools for collection,conservation and efficient utilization of rainwater to improve its productivity in dryland farming system,identifying and integrating appropriate water harvesting techniques in the crop-livestock system of marginal drier environments and developing packages for increased irrigation water productivity through improving irrigation management,use of water efficientcropping patterns,etc.

Rice based cropping system is the most dominant system in the eastern India. It is a water intensive system as rice is the most inefficient user of water with WUE of about 3.7 kg/ha-mm.Rice crop consumes almost 50%of irrigation water in India.Though 3000-4000 litres water is required to produce a kg of rice,the crop consumes about 15000 litres in India as against 6000 litres in Japan.About 55-60% of the applied water in rice field is lost due to deep percolation.Various systems of rice cultivation in rice-based cropping system are followed to reduce the unproductive water outflows(i.e., seepage,percolation and evaporation), which increases water productivity of the system. These are Alternate Wetting and Drying(AWD), Saturated Soil Culture(SSC), System of Rice Intensification(SRI),Aerobic rice,Mulching,etc.

Alternate wetting and drying (AWD): In alternate wetting and drying system, irrigation water is applied to flood the field after disappearance of ponded water.Field water tube is used to monitor the depth of ponded water.When the ponded water drops to 15 cm below the surface of the soil irrigation is applied to re-flood the field with 5cm of ponded water.From 1 week before to 1 week after flowering,ponded water ismaintainedcontinuously at 5 cm depth.Water savings is about 15-30% without any appreciable reduction in yield.

Saturated soil culture (SSC): In SSC, the soil is kept as close to saturation as possible there by reducing the hydraulic head of the ponded water, which decreases the seepage and percolation flows. A shallow irrigation is given to obtain 1 cm ponded water.Water savings varies from 5 to 50 % with yield losses of only 5-10%.

System of rice intensification (SRI): In SRI,irrigation water is allowed in the channels between beds to maintain soil moisture at root zone near saturation.As the field is intermittently irrigated and dried, the roots remain active for long period and the micro organisms grow well which make nutrients available to the plants.The yield increased by 20-30% with water savings of 30-50%.

Aerobic rice: Though puddling reduces percolation loss,it is not a pre requisite for rice production.Aerobic rice is a system of rice cultivation where input-responsive high yielding rice varieties are direct dry sown with no puddling,no standing water and even no soil saturation throughout the crop season.Yields were on a par with irrigated puddle rice with 60% less water consumption.

Mulching : Various mulches in non-flooded rice system are used to reduce evaporation as well as percolation losses while maintaining high yields.Besides, mulching results in earlier crop establishment particularly in cold regions,less weed growth and higher yield.

Uncontrolled watering, improper land leveling,field to field irrigation,mismatch in variety and land,mismatch in variety and water availability,wet-wet canal schedule,minimal supervision are some of the on farm water management constraints in rice.Different water saving agro-techniques developed for rice in eastern India are:

- Proper land leveling and puddling with tractor mounted rotavator or power tiller saves about 10% of water.
- Growing rice in a compact rather than in isolated patches.
- Continuous shallow submergence (5±2)cm than deep submergence (7±2)cm saves 10-50% irrigation water.
- Saturation throughout is optimum in shallow water table (at 20-30 cm depth in *rabi* and 20-45 cm in *kharif*)
- Rotational irrigation at 3 days after disappearance of ponded water (DADPW) during *kharif* (5-7 irrigations) and 1 DADPW during *rabi* season (13-15 irrigations)saves 9-27% water.
- Drainage at maximum tillering (or)even at panicle initiation in iron toxicity area is beneficial.
- Drainage at dough and maximum tillering stages increases head rice recovery by 10%.
- Draining field gradually 15-20 days after flowering facilitates mechanical harvesting,timely sowing of succeeding crops and saves 16-22cm water.
- Rice cultivation in IFS mode improves net water productivity of the system to Rs.7.52/m^3 as against Rs. 1.55/m^3 for sole irrigated rice.

In cropping system prospective,water management in one of the component crops has little or no bearing on water needs or productivity of subsequent crops.Water use efficiency of cropping systems can be increased by identifying appropriate crop combinations.More remunerative and water use efficient cropping systems have been identified for different locations of the country.These are: Rice-mustard-sesame/greengram for West Bengal, rice - lentil/wheat, and soybean - wheat for Tarai region of UP, groundnut - sorghum, rice -gram/mustard-greengram for Maharashtra, sorghum + pigeonpea-maize + fodder maize for Coimbatore, rice-potato-greengram and rice-maize-blackgram for Bihar, rice-maize-cowpea/okra, and rice-groundnut-greengram/sesame for coastaland western Odisha, respectively.

Adoption of rice cultivation systems requiring less and less of water and various water saving agro-techniques in rice-based cropping systems will save the precious scarce resource and will increase the cropping intensity of the country.

Non-puddling for rice

The benefits of the new resource conserving tillage options listed above are lost when rice soils are puddle (ploughed when wet). The RWC is therefore encouraging research on-station and with farmers to find ways to eliminate this soil degrading process. Most rice farmers in South Asia traditionally puddle their soils to help pond water, reduce percolation losses and control weeds. Initial data indicates that rice fields do not need to be flooded after the first few weeks and that puddled soils have more cracking and need more water once the fields dry. Initial flooding though is important to promote tillering and to more effectively control weeds. Studies are also being initiated to determine the exact water balance for the puddled and non-puddled conditions at the field, water course and command level. This is being done for fields where bed planting is practiced and in fields with flat planting, with and without tillage. As mentioned above, farmers feel that bed planted rice saves water over the traditional system. Quantitative data will be available soon to confirm this.

Data presented in figure 5 shows that wheat yields are significantly better when wheat is planted with 0-till after non-puddled rice than after puddled rice. The data also shows that rice yields are similar between puddled and non-puddled situations if weeds can be controlled. This shows that RCTs need to be assessed on a systems basis and not on a single commodity.

Laser levelling

All the above technologies can benefit from levelled fields. This is being promoted in Pakistan as a means to improved water efficiency. However, when this is combined with 0-tillage, bed planting and non-puddled rice culture, plant stands are better, growth is more uniform and yields higher. Use of permanent bed systems and 0-tillage results in less soil disturbance and reduces the need for future levelling. India is also starting work on this and promoting levelling in farmer fields in Haryana and Western UP.

II. Material and Methods

The Methodology is followed as follows 1.By Reviewing various Journals, Articles for Compiling Secondary Data to prove Relative advantages of this method.2.Finally by Using Theoretical Orientation the Research Article will make concrete.

Supplemental water use in eastern India

The winter season following the long rainy season is short in Eastern India. Long-term analysis of the rainfall data clearly indicates that there are three distinct periods of moisture availability. The early moist period (evaporation exceeds rainfall) extends over 12-18 days followed by 93-139 days of humid moist period wherein precipitation exceeds potential evapo-transpiration. This is followed by a moist period of 17-22 days where once again rainfall is less than evapo-transpiration. If the rice seedlings and crop can be established early in the first moist period, before the humid period, the rice crop can benefit from the monsoon rain and grow without the need for irrigation. Timely transplanting of rice also results in earlier harvests and allows timely planting of the next wheat crop. The results of farmer participatory field trials showed that the strategy of timely transplanting of rice improves wheat yields. Rice wheat system productivity was nearly 12-13 tons per ha when rice was transplanted before 28th June. This was reduced by more than 40% when fields were planted after 15th August (to 6-7 tons/ha).

It was also reported that peripheral bunds 18-20 centimeter in height around fields could store nearly 90 percent of total rainwater *in situ* for improved growth and production of rice.

Benefits of the RCT's in terms of water use

Farmers are adopting the new RCT's quickly. Figure 6 shows the rapid adoption of 0-tillage in the region. More than 100,000 ha of wheat were grown that way last year and this is expected to increase to a million in the next few years. Farmer feedback on water savings with these new technologies essentially says that they save water. For zero-tillage, farmers report about 25-30% savings. This comes in several ways. First, 0-tillage is possible just after rice harvest and any residual moisture is available for wheat germination. In many instances where wheat planting is delayed after rice harvest farmers have to pre-irrigate their fields before planting. 0-till saves this irrigation. Savings in water also comes from the fact that an untilled soil has less infiltration than a tilled soil and so water flows faster over the field. That means farmers can apply irrigation much faster. Because 0-tillage takes immediate advantage of residual moisture from the previous rice crop, as well as cutting down on subsequent irrigation, water use is reduced by about 10 cm-hectares, or approximately 1 million liters per hectare. One additional benefit is less waterlogging and yellowing of the wheat plants after the first irrigation that is a common occurrence on normal ploughed land. In 0-till, less water is applied in the first irrigation and this yellowing is not seen.

Farmers also report water savings in bed planting. Farmers commonly mention 30-50% savings in this system. Farmers also indicate that it is easier to irrigate with bed planting. Obviously, half the space is used for water and so less water is used. The question is whether farmers need to apply more number of irrigations with this system. This is being studied in a newly started RWC ADB project in Pakistan and India. In the initial year of planting rice on beds, farmers estimated they used 50-65% less water than on the flat. They kept the beds flooded for the first week, but were then able to cut down on irrigation frequency later. This also needs to be confirmed with good quantitative data.

The On-Farm water Management staff of Pakistan's Punjab comparing RCT farms has collected data on water use efficiency (Gill, 2000). This is presented in table 3 for two locations. All the systems provided better water use efficiency compared to traditional systems. Average water saved with laser leveling, zero-tillage and bed planting over the traditional was 715, 689, and 1329 m^3/ha with a value of rupees 522, 503 and 970 per ha based on a water rate of Rs900/acre-foot for private tubewells for the year 1999-2000. We still need to collect the data for the water use under puddled and non-puddled rice cultivation. Definitely, water percolation will be higher in non-puddled situations, but the total water use may be less since no water is needed for seedling raising or puddling the main field. Also when puddled soils dry, and many farmers cannot keep their fields continuously flooded, soils crack and so the field needs more water to fill the profile when water is next added. Less cracking occurs in non-puddled soils. Data is also being accumulated that the rice crop does not need to be kept flooded the whole season. Standing water is needed early to help tillering and control weeds, but later this is not required.

Importance of participatory technology development

Adoption of RCTs in South Asia has been rapid over the past few years, especially for 0-till with the inverted-T planter. Figure 6 show that more then 100,000 ha was grown last year. This success was possible because of the application of participatory approaches for accelerating adoption. The traditional extension system that was so effective in the early years of the GR was based on development of recommendations and packages and then having the extension service demonstrate the technology to farmers. Seed and fertilizer was easily packaged and it was possible to layout many trials at low cost. When this traditional extension system was used for extending RCTs, problems arose. The first problem was the availability of the machinery to conduct the demonstrations. However, the main constraint was convincing farmers, extension workers and at times scientists that this technology had any benefit. Success came once partners were allowed to work together and experiment with the technology. Local manufacturers had to be involved in the development and manufacture of the equipment. Machinery had to be of high quality, yet at a cost within the budgets of farmers. Farmers had to be shown how the drill worked and then allowed to experiment with the equipment, before he could be convinced to accept this radical technology. Stories abound of how the farmers who first tried the technology were ridiculed by his neighbors for trying something so alien. But once the seed germinated, farmers begged the innovator to help them sow their fields. It is now felt that 0-till wheat is an acceptable technology and will be part of the recommendations for planting wheat. Similarly, other RCTs like bed planting will become accepted practices, as machinery is made available and more farmers experiment with the system.

One question that is often asked is "who can benefit from this technology? Is it just for the large, commercial farmer?" The answer appears to indicate that this technology is scale neutral and that farmers from all social classes can benefit from the many advantages that this system brings to wheat cultivation. A survey conducted in Haryana in 2001 of 20 villages and 91 farmers showed that 24% of the 0-till adopters owned a tractor while the rest used service providers. The average farm size of adopters ranged from 0.8 to 20.2 hectares. Twenty two percent had less than 2 ha and 37% from 2-4 ha farms. All but one farmer agreed that 0-till was highly profitable and data shows that 0-till resulted in US$75/ha more than with conventional practices. Yields from 0-till were 5.4 versus 5.1 t/ha for conventional. Resource poor farmers and farmers without tractors are using contract services to plough their fields at the moment. It is becoming too expensive to keep a pair of bullocks just for land preparation and so using a service provider is more economic. When this is applied to 0-till or bed planting, the benefits are even more pronounced. In this case, the farmer has only to rent the service once and his fields are planted. This saves him money and time to do other activities. Data from socio-economic and impact assessment surveys in India and Pakistan show this to be true. The first innovators are larger, better endowed, tractor owners. Later less endowed farmers adopt the technology as they see the benefits and obtain the services for this technology.

Farmer responses and feed back to the RCT's and especially 0-tillage provide valuable feedback to scientists in the RWC for improving the technology. At the same time, scientists have been monitoring the fields where these technologies are being adopted and collecting data on soil, biotic, and resource use.

CONCLUSIONS

The paper has described various resource conserving technologies available for testing in the RW systems of the India. It describes the benefits to the region of farmers adopting various resource conserving technologies in terms of improved production at lower cost, improving the efficiency of natural resources, benefits to the environment, improved livelihoods of farmers and ultimately help in alleviating poverty. Water is particularly highlighted since farmers indicate that all the technologies result in water savings. There is a research need to more accurately measure these savings and a recent ADB project will do just that. It is also important to look at water balances at different scales to determine if water savings at the field level will also give savings at the watercourse, command and basin level.

The success of this technology is dependent on rapid adoption by farmers. Accelerated adoption was mainly the result of the change in paradigm for extending the technology. Instead of the linear approach to extension commonly found in the Green Revolution era, the importance of partnerships, expanded stakeholders, and participatory approaches where farmers could experiment and feedback information soon became apparent. Resource conserving technologies are a key to ensuring sustainable food production in South Asia in the next decade. Overcoming mindsets that hold traditional beliefs about excessive tillage and providing the enabling factors that allow exposure of the technology to all those involved in agriculture will be key factors for future success. This technology revolution is seen as one way to sustainably increase food production to meet future demands while conserving natural resources, improving farmer livelihoods and reducing the negative effects on the environment. Water is listed high on the list of natural resources and its use and productivity can definitely be improved with these new technologies. Of course, all of these benefits will be of little use unless nations in South Asia control their population growth.

ACKNOWLEDGEMENT

We are thankful to our friends, philosopher and guides for their timely help and bow our head before almighty for achieving this success for society.

REFERENCES

[1] Aslam, M., A. Majid, N.I. Hashmi, and P.R. Hobbs. 1993. Improving wheat yield in the rice-wheat cropping system of the Punjab through zero tillage. Pakistan Journal of Agricultural Research 14: 8-11.

[2] Christian, D.G., and E.T.G. Bacon. 1990. A long-term comparison of ploughing, tyne cultivation and direct drilling on the growth and yield of winter cereals and oilseed rape on clayey and silty soils. Soil and Tillage Research 18: 311-331.

[3] Duxbury, J.M., I.P. Abrol, R.K. Gupta, and K.F. Bronson. 2000. Analysis of long-term soil fertility experiments with rice-wheat rotations in South Asia. p.7-22. In Abrol, I.P., K.F. Bronson, J.M. Duxbury and R.K. Gupta (ed.). Long-term soil fertility experiments with rice-wheat rotations in South Asia. Rice-Wheat Consortium Paper Series No. 6. Rice-Wheat Consortium for the Indo-Gangetic Plains, NewDelhi.

[4] Dawe, D., A. Dobermann, P. Moya, S. Abdulrachman, Bijoy Singh, P. Lal, S.Y. Li, B. Lin, G. Panaullah, O. Sariam, Y. Singh, A. Swarup, P.S. Tan, and Q.X. Zhen. 2000. How widespread are yield declines in long-term rice experiments in Asia? Field Crops Res. 66:175-193.

[5] Harrington, L.W., S. Fujisaka, M.L. Morris, P.R. Hobbs, H.C. Sharma, R.P. Singh, M.K. Chaudhary, and S.D. Dhiman. 1993. Wheat and Rice in Karnal and Kurukshetra Districts, Haryana, India: Farmers' Practices, Problems and an Agenda for Action. Mexico, D.F.: Haryana Agricultural University (HAU), Indian Council for Agricultural Research (ICAR), CIMMYT, and the International Rice Research Institute (IRRI).

[6] Gill, M.A., M.A. Kahlown, M.A. Choudhary and P.R.Hobbs. 2000. Evaluation of resource conservation technologies in rice-wheat system of Pakistan. Report of the OFWM division, Punjab Government, Lahore, Pakistan.

[7] Hobbs, P.R., and M.L. Morris. 1996. Meeting South Asia's Future Food Requirements from Rice-Wheat Cropping Systems: Priority Issues Facing Researchers in the Post Green Revolution Era. NRG Paper 96-01. Mexico, D.F.: CIMMYT.

[8] Hobbs, P.R., Singh, Y., Giri, G.S., Lauren, J.G., and Duxbury, J.M. 2001a. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gangetic Plains of South Asia. In: Proceedings of the workshop on direct seeding in Asian rice systems. IRRI, Los Banos, Philippines, in press

[9] Hobbs, P.R. 2001b. Tillage and crop establishment in South Asian rice-wheat systems: present and future options. In: Kataki, P.K. ed. The Rice-Wheat Cropping System of South Asia: Efficient Production Management. Journal of Crop Production, Volume 4, number 1. pp. 1-23.

[10] Kuipers, H. 1991. Agronomic aspects of ploughing and non-ploughing. Soil and Tillage Research 21: 167-176.

[11] Malik, R.K., and S. Singh. 1995. Littleseed canarygrass resistance to isoproturon in India. Weed Technology 9: 419-425.

[12] Malik, R.K. 1996. Herbicide resistant weed problems in developing world and methods to overcome them. *In* Proceedings of the 2nd International Weed Science Congress. Copenhagen, Denmark. Pp. 665-673. FAO, Rome.

[13] Malik,R.K.; Gill,G.; Hobbs,P.R. 1998. Herbicide resistance - a major issue for sustaining wheat productivity in rice-wheat cropping system in the Indo-Gangetic plains. Rice Wheat Consortium Research Paper series number 3. 36 pp. New Delhi, India: Rice Wheat Consortium for the Indo-Gangetic Plains.

[14] Meisner,C., Acevedo,E., Flores,D., Sayre,K, Ortiz-Monasterio,I., Byerlee,D. 1992. Wheat production and grower practices in the Yaqui valley, Sonora, Mexico. Wheat Special Report #6. CIMMYT. Mexico DF.

[15] Regmi, A.P., J.K. Ladha, E.M.Pasuquin, H. Pathak, P.R. Hobbs, M.L. Shrestha. 2001b. Importance of Potassium in Sustaining Yields in Rice-Wheat System in Indo-Gangetic Plains of Nepal. (submitted to Agronomy Journal).

[16] Regmi, A.P., J.K. Ladha, H. Pathak, E. Pasuquin, C. Bueno, D. Dawe, P.R. Hobbs, D.Joshy, S.L. Maskey, and S.P. Pandey. 2001a. Analyses of Yield and Soil Fertility Trends in a 20-Year Rice-Rice-Wheat Experiment in Nepal. (submitted to Soil Science Society of America).

[17] Sayre, K.D., and O.H. Moreno Ramos. 1997. Applications of Raised-Bed Planting Systems to Wheat. Wheat Program Special Report No. 31. CIMMYT, Mexico, D.F.

[18] Sayre, K. D. 2000. Effects of tillage, crop residue retention and nitrogen management on the performance of bed-planted, furrow irrigated spring wheat in northwest Mexico. Presented at the 15th Conference of the International Soil Tillage Research Organization; July 2-7, 2000; Fort Worth, Texas, USA.

[19] Sheikh, A.D., M.A. Khan, M. Aslam, Z. Ahmad, and M. Ahmad. 1993. Zero Tillage Wheat Cultivation Technology in the Rice-Wheat Areas of the Punjab. Pakistan, Islamabad: National Agricultural Research Council (NARC).

[20] Singh, Y. 1995. Rice-Wheat Cropping System NARP Basic Research Sub-project. Progress Report 1994-95. G.B. Pant University of Agriculture and Technology, Pantnagar, U.P., India.

[21] Verma, U.N., and V.C. Srivastava. 1989. Weed management in wheat under zero and optimum tillage conditions. Indian Journal of Agronomy 34: 176-179.

[22] Verma, U.N., and V.C. Srivastava. 1994. Production technology of non-tilled wheat after puddled transplanted rice. Indian Journal of Agricultural Science 64: 277-284.