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Coping groundwater depletion through scientific agronomical practices in Hard-rock areas of Nalgonda District, Telangana

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ABSTRACT

The Mandollagudem TECHVIL Cluster located in Nalgonda District, Telangana falls under drought prone area as it receives an average rainfall of 620 mm. The region is characterised by low infiltration of surface water and poor connectivity between the aquifers. Groundwater levels dropped significantly during the past decade due to the over exploitation of ground water induced by the shifting of crop pattern from Castor/Cotton to paddy cultivation in addition to the exogenous processes. Since it is very difficult to suddenly shift to new crop, we suggest that the adoption of the System of Rice Intensification (SRI) method along with Alternate Wetting and Drying (AWD) and Direct Seeding (DS) methods will reduce the consumption of water up to 30 percent with more grain productivity compared to continuous uncontrolled flooded field methods. From the statistical analysis of various data sets, it is concluded that the adoption of low water consuming crops and scientific irrigation practices are the most recommended solutions to mitigate the drastic depletion of groundwater levels.

INTRODUCTION

Mandollagudem, located in Choutuppal Mandal of Nalgonda district, Telangana is one of the 25 TECHVIL (technological villages) identified from 25 backward districts of India under CSIR-800 program. The aim of the CSIR-800 programs is to improve the living standard of the 800 million Indian citizens from rural areas through science and technology. The study area is underlain by Archaean group of rocks comprising older metamorphic rocks (hornblende/biotite schists, granulites, amphibolites, etc.,) and Peninsular Gneissic Complex comprising grey granite gneiss, migmatitic gneiss, porpheirtic granite (pink) with quartz, epidote, and dolerite intrusives. The water table follows the general topography of the area with south-eastern directional groundwater flow. The water table shows a depth variation of 50m i.e., 325m (amsl) in west to 275m (amsl) in the east. A variation of 10m is revealed between the pre-monsoon and post monsoon groundwater levels of one year as reflected by 18 to 22 m in pre-monsoon period (2002) and 8 to 12 m in post-monsoon (Reddy et al., 2010).

STATE OF ISSUE

To get a clear picture on the socio economic and domestic problems of the people from this region, we have conducted meetings, visited gram panchayat, schools and gathered common health history of the residents from Heath centres. We have closely analyzed the important issues and needs of the TECHVIL people to enrich their livelihood through scientific solutions. The discussions made with the people of different age groups during the visits to the village helped in identifying and analysing the major problems. The ground water scarcity, fluoride problem, and un-employment are the critical issues for the backwardness in the region of which water quantity and fluoride problem are the two major issues that require scientific intervention/attention. In the present study, the effects of agricultural patterns on water quantity are studied.

DATA

The annual rainfall data used in the present study was deduced from the real time rainfall data measured by National Geophysical Research Institute (NGRI) at Choutuppal Observatory, Nalgonda District, Telangana state. Land usage data was collected from Agriculture department, while the other relevant information on the life style and agriculture practices are adopted from the survey reports of CSIR-800 project.

AGRICULTURE AND GROUNDWATER

A decade back, castor, cotton and red gram were the common crops in this cluster. The farmers shifted to paddy cultivation recently due to its high profits. In the present work, we analysed the scientific methods of paddy cultivation to address the groundwater decline in the study area, which is mainly due to low rainfall and over extraction. The low rain fall can be clearly noticed from the annual rainfall pattern of past ten years (Fig.1) measured at NGRI Choutuppal Observatory, while the over extraction of the ground water could be understood from the statistics of surface and groundwater based land irrigation presented in the Table 1.

Table 1. Land used for irrigation in the TECHVIL cluster (Agriculture department, Choutuppal Mandal, 2012)

Area irrigated	10661 Acres
Surface irrigation	100 Acres
Ground water irrigation	10561 Acres

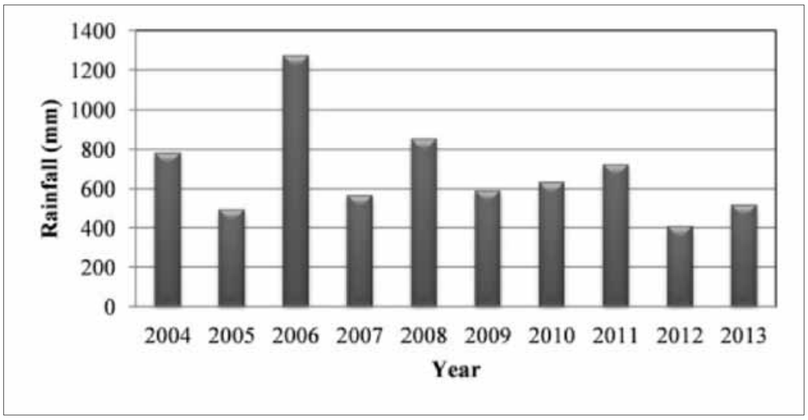

Figure 1. Annual rainfall pattern during last decade.

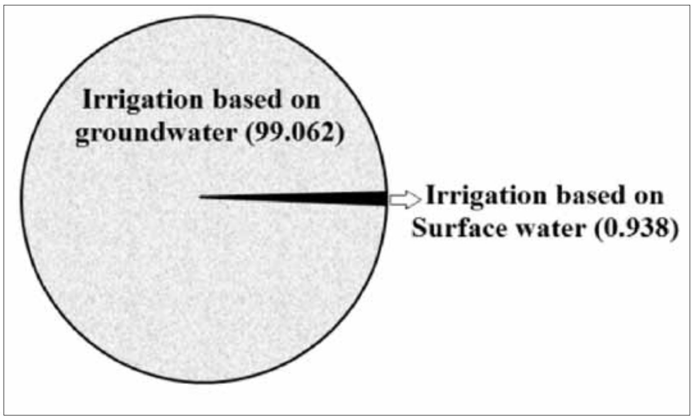

Figure 2. Percentage of ground and surface water resources used for irrigation

It is clear from the Fig.2 that 99% of agriculture depends on ground water, as revealed by the percentage of surface and ground water utilization for irrigation.

In order to reduce the groundwater depletion, advanced cultivation methods are to be adopted to ensure sustainable cultivation (Lampayan, 2013; Bouman et al., 2007). Particularly in Indian scenario, paddy alone consumes about half the water used for total agriculture among the various crops. Hence, the rapid depletion of the water table can be controlled either by replacing the paddy with other crops or by adopting the advanced methods of paddy cultivation with minimal usage of water. In conventional method of paddy cultivation, the fields are kept under three to four inches of water to prevent growth of weeds. The transplantation of seedlings also requires extensive use of water resources. So, the conventional paddy cultivation over the past decade in the study area is basically responsible for the fall in the water table. In addition, the depletion is aggravated by less rainfall than the average of 620mm during the last two years in the study region. The scientific methods of paddy cultivation and their advantages are as follows.

SCIENTIFIC METHODS OF PADDY CULTIVATION

In the present work, we discuss three efficient methods of paddy cultivation. The farmers from many countries including India have already been adopting the System of Rice Intensification, Alternate Wetting and Drying and Direct Seeding methods to overcome groundwater shortage problem.

System of Rice Intensification (SRI)

The SRI method (Barah, 2009; Basavaraja et al., 2008; Sinha and Jayesh, 2007) developed in Madagascar during 1980s by Father Henride Laulanie is in practice at present in many Asian and African countries. The SRI method involves only reorganizing the management of available resources. SRI is a technological breakthrough in paddy cultivation involving the application of certain management practices, which together provide better growing condition for rice plants, particularly in the root zone, than those of plants grown in conventional flooded methods. Synergistic interaction leads to much higher yields in SRI than conventional methods. India has the world's largest area devoted to rice (paddy) cultivation, a very water-intensive crop. As such, it is essential to adopt scientific cultivation practices, ensuring "more crop per drop". The SRI method was first tried and demonstrated in Tamil Nadu during 2000-01. The SRI method helped in higher rice production, with less water. In Krishna western delta command area of Andhra Pradesh (A.P) it is noticed that SRI is a less water consuming method of rice cultivation when compared to the conventional method, semi dry method and rotational method of rice cultivation (Radha et al., 2009). SRI method, as detailed below, differs from the conventional method of rice cultivation.

Nursery Management: Prepare seed bed by a well mixture of farm yard manure (FYM) and soil either on polythene covers, banana sheaths or on soil itself. 5 kg seed per hectare is sufficient against 50 to 62.5 kg used in conventional method. The 8 to 12 days aged seedlings transplantation with two small leaves and seed attached to the plant as against the transplantation of 25 days old seedlings in conventional rice cultivation practices.

Transplanting to main field: The seedlings should be removed carefully from the nursery without disturbing the roots of the plant along with seed. Single seedling should be transplanted per spot in the main field. Before transplanting seedlings, water in the main field must be drained out.

Wide spacing: Wider spacing of 25 x 25 cm in square pattern should be maintained for better aeration and for easy intercultural operations due to line plantation with the help of rotavator as against 50 to 60 hills per square meter in conventional method.

Weeding: Naturally, weed growth is more in SRI method because there is no stagnated water. Weeding should be done with rotary weeder/ conoweeder for at least four times with an interval of 10 days starting from tenth day after planting. It churns the soil and the weeds incorporated in the soil. This process of churning the soil and weeds leads to in situ preparation of organic manure. It helps in increased soil aeration and health.

Water management: The soil should be kept moist to maintain wetness and avoid cracks in the soil. It is essential to ensure optimum water saturation of the field/ farm by providing periodic wetting and drying.

Manure and fertilizer: Application of more of organic manures i.e. 8 tons per ha should be used and application of fertilizer needs to be organized based on soil test results.

Alternate Wetting and Drying (AWD)

Alternate Wetting and Drying (AWD) is an established method to reduce the water consumption in rice irrigation (Oliver et al., 2008). Reduction of water consumption up to 30 percent can be achieved through cycle of alternate low-level flooding, which can be monitored through water levels in the field level gauge called Pani Pipe with no reduction in the yield. The Pani Pipe is a 40 cm long plastic or bamboo pipe of 15 cm diameter with drilled holes, which is sunk into the rice field to a 20 cm depth (Rest of the pipe protrudes above the ground). When the water level inside the pani pipe drops to 15cm below ground level, the field is ready to be re flooded. The physical appearance and field operation of the Pani pipe can be seen from Fig.3.

This threshold of 15 cm is called 'safe AWD' as it does not have any impact on yield. Rice has a high risk of zinc deficiency, even though the soil contains adequate zinc due to long term flooding in conventional irrigation. This will cause stunting, poor tillering , grain filling and low yields. AWD promotes higher zinc availability in the soil and grains by enabling periodic aeration of the soil, which releases zinc from insoluble forms to be available for plant uptake. Finally, AWD reduces water consumption by 30%, solves zinc deficiency problem and also reduces the methane emissions. SRI along with this AWD method would result in high yield ,while saving more water. Fig.4 indicates the statistical comparison of SRI-AWD with conventional flooded field methods.

Direct Seeding Method (DSM)

DSM (Pathak et al., 2011) became popular during the Green Revolution in the 1960's, as it enhanced productivity. The DSM of rice involves sowing seeds directly in the fields with the help of a machine. This is different from the conventional method where seeds are first germinated in a nursery for up to four weeks, and then the saplings are transplanted into the fields. DSM avoids three basic operations namely, puddling (a process where soil is compacted to reduce water seepage), transplanting and standing water, thereby save about 30% water (0.9 million liters of water/acre). The critical success factors for direct seeding are (i) Proper seed germination, plant population and its geometry (ii) Nutrition & management of micronutrient deficiency (iii) Management and control of weeds. To maintain Proper seed germination, plant population and its geometry, PepsiCo has developed a

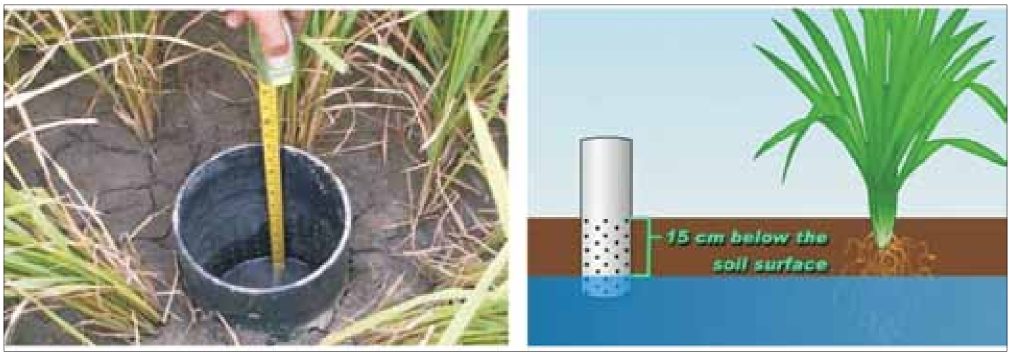

Figure 3. Panipipes used to monitor the water level in AWD method

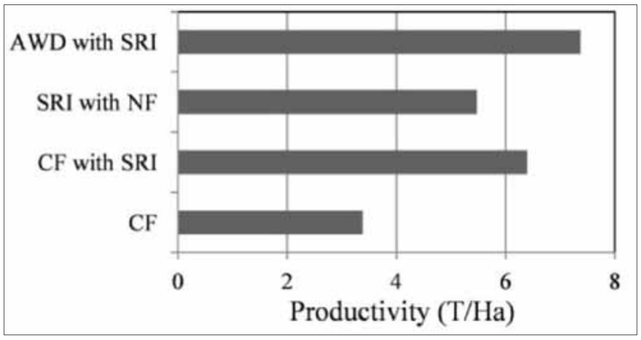

Figure 4. Comparison of yield (Tons/Ha) in Completely Flooded (CF), Non Flooded (NF) paddy cultivation practices with SRI and AWD methods.

Figure 5. Direct seeder developed by PEPSICO for DSM.

tractor driven direct seeding machine. The machine has been designed to sow the seeds at a depth of 1-1.5 inches to provide good germination. This direct seeder (Fig.5) has a unique seed-metering device, which ensures planting of the seeds 8-9 inches apart (4-5 seeds falling at this distance) and also maintains a row to row distance of 9 inches. The machine ensures about 30-32 plants / sq meter.

Seed Priming: Seed priming is soaking and treatment of seeds before actual seeding through the machine. This is a very important operation, which helps to improve germination and control of seed borne diseases. The seed is soaked in solution having fungicide and antibiotics (Emisan and Streptomycin) for 15-20 hours. The seed thus treated is dried for 1-2 hours in shade so that it can be dispensed efficiently from the machine.

Nutrition & management of micronutrient deficiencies Since direct seeding follows aerobic cultivation of paddy, it usually results in certain micronutrient deficiencies, namely Zn, Fe & Sulphur and also P among macronutrients. These deficiencies are corrected by application of cheated Zinc and Ferrous fertilizers. To avoid nutritional deficiencies, fertilization should be scheduled as mentioned in Table 2.

Table 2: Schedule of Fertilizers to manage micronutrients deficiencies in DSM

Time of Fertilization	Fertilizer (in Kgs / acre)				
	Urea	DAP	MOP	Librel Zinc	Librel Fe
At the time of sowing	15	25	20	0.5	0.5
20 days after sowing	15-20	0	0	0	0
35 days after sowing	10-15	0	0	0	0

At the time of sowing, 25 kg of DAP, 0.5 kg of Librel Zinc and 0.5 kg of Librel Fe are used and the remaining fertilizers are sprayed/ broadcast at different timings. To overcome the deficiencies of Zinc and Iron, 2 gm Libmix per litre of water is sprayed after 30 - 35 days of sowing. The ground application of 2 kg Librel Sulphur per acre is needed to overcome Sulphur deficiency. The weed problem can be overcome by using herbicides.

DISCUSSION

SRI method can be adopted in both the cases of Continuously Flooded fields or Non-flooded fields .SRI yields more grains compared to conventional method. Apart from yielding, we can reduce water consumption by 10 to 25%. The increase in the production observed from the same variety of rice crop using SRI and Non-SRI Methods is shown Fig.4. As we are facing acute water scarcity coupled with soil degradation, shrinking land resources and adverse impacts of climate change, the adoption of SRI method could provide better opportunities to millions of farming households. Using AWD technique, farmers can save up to 30% of water. The zinc deficiency induced by long term flooding causes stunting, poor tillering and grain filling and low yield. The AWD promotes higher zinc availability in the soil and grains by enabling periodic aeration of the soil, which releases zinc from insoluble forms and makes it available for plant uptake. Thus, the problems arising due to zinc deficiency are intermittently solved in AWD method. AWD requires less water, solves zinc deficiency problem and also reduces the methane emissions. If we use SRI along with this AWD method, we can produce high yield with less water. **Fig.4** indicates the statistical comparison of SRI-AWD with conventional flooded field methods. Apart from the resulting substantial reductions in water consumption, direct seeding also assures significant cost savings for the farmer. The DSM with AWD must be verified experimentally under the supervision of agriculture institutions such as Central Research Institute for Dry land Agriculture (CRIDA), Hyderabad. Thus, by adopting these techniques, on a long run, we can see the increase of groundwater level in the study region. This in turn may also dilute the concentration of fluoride, thereby solving the fluoride problem to certain extent.

CONCLUSIONS

From the present study, we have arrived at the conclusion that the shifting of agriculture practices to the low water consuming, economically profitable crops would help the farmers in sustaining agriculture. It is essential to select area specific alternate crops, using expert advice. However, as the farmers have shifted to rice cultivation only in the recent past , to ensure organised agriculture practices in rice cultivation (without abnormally depleting ground water), it is essential to conduct on spot exercises to impress upon the farmers the need to shift to SRI –AWD irrigation. Since there is a possibility that even the suggested SRI-AWD irrigation practices may not be feasible in the long run due to global warming related monsoon aberrations, it is essential to advise the farmers to gradually shift to more profitable medicinal and aromatic plant cultivation (using CSIR –CIMAP support) without incurring financial losses (P.S: Since medicinal plant cultivation needs organised cultivation, packing, transportation and marketing practices farmers need to be constantly guided, as any noncommittal attitude in cultivation may lead to losses). To start with, 25 % of the cultivable land may be taken up for medicinal and aromatic plant cultivation with the rest of 75 % of land irrigated for rice. In addition to ensure no financial loss due to shifting of cropping pattern, the farmers need to be guided on a regular basis, starting from selection of seeds etc. Also, if the farmers find it difficult to adapt to new crops, the CRIDA, CSIR-CIMAP, and rural agriculture departments should come forward to guide them.

It is succinctly demonstrated that adoption of advanced technologies in paddy cultivation is a solution to mitigate the drastic depletion of ground water level. The combined usage of SRI-AWD will be a better practice to follow as it saves money and more importantly, the water. The joint usage of DSM-AWD should be verified on experimental basis in different situations and popularised among the farmers, as it saves more water with high yield. The training programs by the Agriculture officers will give a scope for the villagers to practice the advanced technology on scientific irrigation. The agriculture officers should also monitor the usage of fertilizer in view of fluoride contents, as the people from this region are already suffering with fluorosis. The ground water depletion and quality need to be monitored on a regular basis. The ill effects of the over exploitation of ground water and its impact on overall well being of the farmer should be given wide publicity through electronic media and brought to the notice of the villagers through community participation.

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