

Closed sub-surface drainage to ameliorate waterlogging and salinity in a canal command area

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Reclamation of saline, saline-alkali and waterlogged soils formed due to the intrusion of flood waters can effectively be done by the closed sub-surface drainage (CSSD) technology. The CSSD technology is appropriate under the salinity and water logging conditions to leach out the excess and harmful salts with excess water from the root zone to provide a better environment to the plants to grow. In south Gujarat, CSSD technology was installed in Patel's farm situated at Virpor and Ghala village, Taluka Choriyasi, District Surat of Gujarat in the command of Surat branch under Ukai Kakrapar (UKC) irrigation project. With successful operation of the system installed during 2012-13 at farmers filed, the water logging problem has reduced and average water table has been lowered from 36.5 to 50.0 cm. The soil salinity has been reduced from 6.7 to 3.5 Ds/m. The sugarcane yield has increased from 58 to 96 t/ha i.e. 65.5 % higher than areas not adopting CSSD technology. The farmers are happy and express the satisfaction over the performance of dual purpose subsurface cum irrigation system.

Keywords: Closed sub-surface drainage, PCV pipe, Soil salinity, Sugarcane, Waterlogging

IRRIGATION projects play a pivotal role in enhancing the crop productivity, livelihoods of the farmers and prosperity to the area. However, if the irrigation facility developed is not properly utilized, then the natural resources viz., soils and crops/vegetation may be deteriorated to such an extent that they become unproductive. Though drainage is envisaged in project document of each and every command, seldom it receives due attention after commissioning of the project. The introduction of irrigated agriculture, however, has resulted in the development of the twin problems of water logging and soil salinization. Farmers apply huge quantities of canal water assuming more irrigation could bring more yield. Furthermore, the introduction of canal irrigation not only brings the much needed water, but also imports salts as irrigation water contains

considerable amounts of salt. In many canal commands, there has been a rise in the water table and consequent degradation of soils through water logging and secondary salt build-up. Further the impact of irrigation over many years have caused the ground water table to rise into root zones in these command areas, which led to reduction in crop yields. The time required to appear these problems and their severity vary with soil type, cropping system adopted by the farmers, maintenance of the canals and presence of network of natural drains in the command areas.

Indiscriminate and excess use of water by farmers and faulty irrigation application system, the worst fears came true in the form of water logging and secondary salinization particularly in low lying areas of Ukai-Kakrapar Command (UKC) on river Tapi in South Gujarat. In UKC

area, 15% of land is actually suffering from these problems and another 25% land is critical mainly due to high clay containing soils, adoption of faulty irrigation methods (flooding, field to field etc.) by ignoring the land irrigability classification. Besides, inclination towards high water consuming crops like paddy, sugarcane, banana etc., by neglecting suggested cropping pattern and heavy rainfall (1,400 mm).

Under these circumstances, subsurface drainage is considered as a most suitable approach for removal of excess groundwater from the crop root zone system which promotes safe environment for efficient crop growth. Moreover, subsurface drainage has been found to be the only solution for providing land reclamation on a long-term basis when salts are present in the soil and groundwater. The scientists have



Fig. 1. Installation of sub-surface drainage

planned proper drainage and other land planning initiatives. Development of efficient drainage system and its maintenance, provision of interceptor and collective surface drains, plantation of bio-drainage trees resulted into lowering of water table and farmers are able to cultivate their land. The farmers of UKC have not simply adopted the CSSD in affected area, but they are also doing some modifications in the system, so as to meet their site-specific requirement. Many farmers have been benefited with this achievement but Patel's farm at Virpor and Ghala village, Taluka Choriyasi, Surat district, Gujarat, emerged as a leader in adopting the package of technologies for reclaiming barren land due to water logging and salinity (Fig. 1 and 2), the success story is addressed here.

Farmers details: The closed subsurface drainage has been installed on the fields of Shri Morarbhai Koyabhai Patel, Head of family, Shri Balvantbhai Morarbhai Patel and Nayanbhai Morarbhai Patel are the son at Virpor and Ghala village, Taluka Choriyasi, District Surat of Gujarat state in the command of Surat branch under Ukai Kakrapar irrigation project with the technical support from Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, Gujarat.

Objective: The basic objective of drainage is to remove excess water from the waterlogged fields. Further, it also helps in reducing secondary salinization/ sodicity problems from

the field. The other problems related to water logging conditions are poor growth and yield of crops, land workability (preparation) and higher infestation of pest and diseases are the problems due to continuous wet condition i.e., *vapsa* condition is not attained. All these aspects have negative impact on crop growth and ultimately reduce yield. Subsurface drainage installation helps in lowering the water table below root zone by draining excess water and also reclaiming the salt affected soils.

General characteristics and history of fields: The soils are heavy with more than 48% clay. The soil is moderately alkaline in reaction, and high in soil salinity. The soil salinity in most parts of the area is higher than 6.5 dS m^{-1} at all the depths. On the basis of electrical conductivity of saturation extract (ECe) of soils, most of the area has been identified as saline. The water table of this area is highly fluctuated and observed at soil surface during monsoon season and 1.5 m deep inside the ground during summer season. Rainfall is

very high during mid July to August.

Earlier, farmers used to grow cotton and pigeon pea in this area. However, they shifted to sugarcane with the availability of Ukai Kakrapar irrigation. the said farmer with the 10 acres of fertile land, recalled the happiness of his elders when canal water was made available to their land. Patels were very happy to irrigate their field and getting good yield of sugarcane and their family was prospering. The number of irrigations varied from 12 to 14 times during the entire crop growth period of sugarcane crop. The canal water has a salinity of 0.3 dS m^{-1} , thus an irrigation gift of 1,600 to 2,000 mm yr^{-1} added 3.5 to 4.0 t ha^{-1} of salts to the soil profile. He was irrigating their field as much as possible but slowly he realized that problem of waterlogging (within 1 to 1.5 m below ground level) building up in their land due to low lying topography, over irrigation and low permeability of soil. Moreover, seepage of canal contributed major share of this water and the whole area



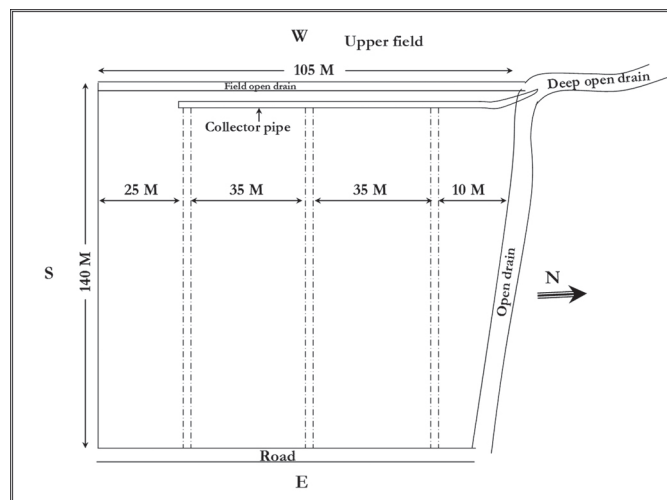
Fig. 2. Crop after installation of CSSD

became muddy and there was no way to drain out the excess water. The natural drains were choked with weeds like *Typha*, *Lantana* and *Ipomea*. Unable to get the proper yield, he was very worried and realized that over irrigation and unscientific practices have made his land barren. Meantime, the farmers heard some technology about drainage and consequently they visited the Soil and Water Management Research Unit, NAU, Navsari. They interacted with the scientists and were happy to know about the subsurface drainage technology which can get rid of the water logging as well as salinity and sodicity of their field. As suggested by the scientists, the farmers followed the guidelines for reclamation in their own lands. With full enthusiasm and motivation, he helped the scientists in all respects and he was happy that the drainage which earlier was choked with weeds was cleared with the use of herbicides as suggested by the scientists. The University recommends subsurface drainage for waterlogged and salt-affected lands besides addition of organics (manures and green manure). Farmers themselves bore the expenditure on the subsurface drainage system. Now, they realize the importance of maintaining the proper drainage in the field.

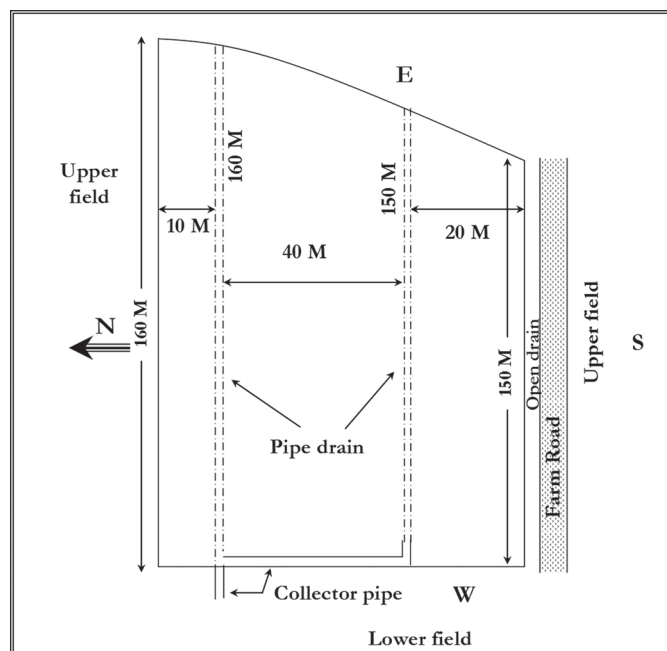
Drainage technology technical details

Corrugated PVC pipes with a diameter of 80 mm were used for the field drains and rigid PVC pipes with diameters of 180 mm

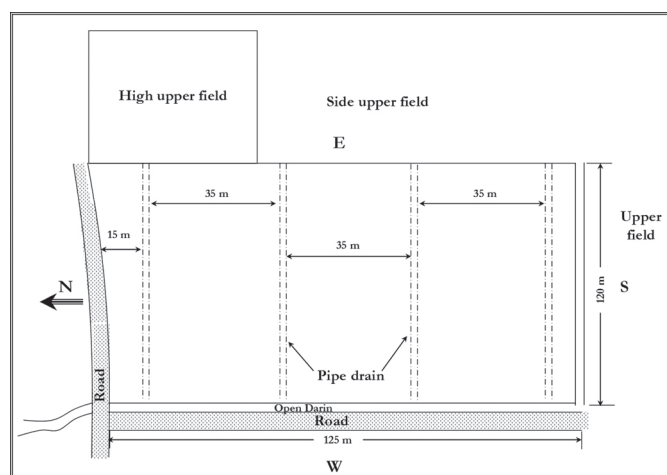
Fig. 3. Closed sub-surface drainage system layout



Farmer's name: Morarbhai Kalidasbhai Patel, Village: Virpor, Taluka: Mandvi & Dist. : Tapi, Block No. 184, Area. 1.47 ha.



Farmer's name: Nayanbhai Morarbhai Patel, Village: Ghala, Taluka: Kamrej & Dist. : Surat, Block No. 314 Area. 2.40 ha.



Farmer's name: Balvantbhai Morarbhai Patel, Village: Ghala, Taluka: Kamrej & Dist. : Surat, Block No. 314 Area. 1.50 ha.

for the collector drains (Fig. 3). Subsurface drainage with PVC corrugated pipes were laid at 35-40 m between two drains and at an average depth of 1-1.5 m. Price of PVC corrugated pipe was around ₹ 85/m. The cost include excavation trench using JCB, labour cost for laying of pipe corrugated pipe and refilling on trench, cost and laying of PVC pipe as conveyance connecting corrugated pipe to nallas outside field was around ₹ 25,000 to 30,000 per ha.. Overall, cost of the system was around ₹ 40,000 to 55,000 per ha.

The system works by gravity and drainage water disposed in to the stream, which ultimately carries it to the Tapi River, about 1.2 km away from the farmers' fields. At one of the main closer drainage, farmers have made provisions to drain surface water into it, in the event of surface stagnation due to excess rainfall. The collector pipe thereafter is of rigid PVC pipe. Whenever required, fresh water is pumped from the stream/nala and put into rigid collector through pump stand. The collector line is used as lift irrigation pipeline to irrigate the fields. Thus, farmers are using collector line for surface drainage, subsurface drainage and irrigation. Because of multiple uses of the system they are also taking care of the system themselves.

Increase in sugarcane yield and economics

Sugarcane yield from the closed subsurface drainage system were from 87 to 105 t ha⁻¹,

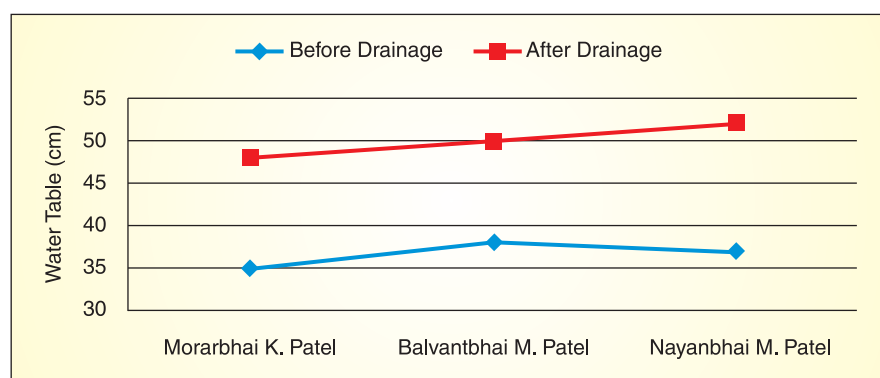


Fig. 4. Impact of Closed Sub-Surface Drainage System on ground water table

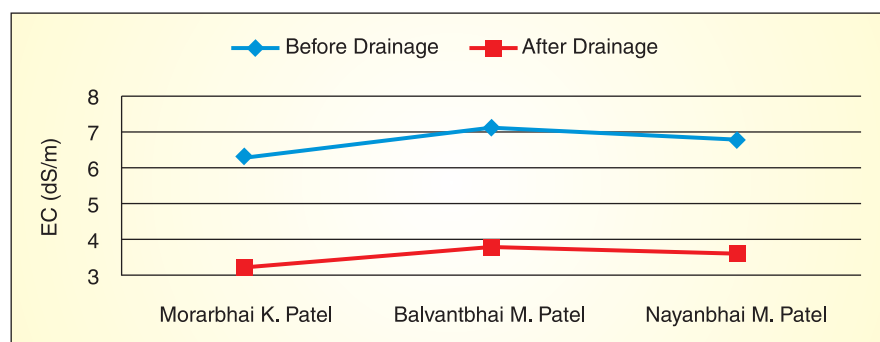


Fig. 5. Impact of Closed Sub-Surface Drainage System on soil salinity

Table 1. Impact of CSSD System on sugarcane crop production and economics

Farmers name	Crop	Crop yield (t ha ⁻¹)		Increase in yield (%)	Cost of cultivation (₹/ha)	Net income (₹/ha)	BCR
		Before	After				
Morarbhai K. Patel (Head)	Sugarcane	62	96	54.8	126,000	220,800	1.75
Balvantbhai M. Patel (Son)		60	105	75.0	130,000	241,500	1.86
Nayanbhai M. Patel (Son)		52	87	67.3	125,000	200,100	1.60
Average		58	96	65.5	127,000	220,800	1.74

Note: Sugarcane: ₹ 2,300/tonne (average of three year)

however, average yields obtained under closed subsurface drainage systems were noticeably significant i.e. 96 t ha⁻¹ that was 65.5% higher compared to areas without installation of CSSD system areas that produced only 58 t ha⁻¹. Subsurface drainage drain excess soil water and salt from the rhizosphere, that keep the soil moisture and aeration and favours the crop growth. Quantifying the influence of this system on the salinity of drainage water indicated that electrical conductivity (EC) and total salt load decreased markedly. Looking to the performance of sugarcane crop yields, it was increased with the installation of subsurface drainage system. The results showed direct relationship

between improvement of system performance and increasing in sugarcane yield, followed by a rise of the economic returns. An economic analysis showed that the cost of installing subsurface drainage systems was readily justified by annual increase in sugarcane yield.

Reduction in ground water table due to Closed Sub-Surface Drainage System

The mean water tables observed goes lower from year to year as expected. The water table range from 35–38 cm (average: 36.5 cm) below ground level before CSSD was lowered down that reached at 47–52 cm (average: 50.0 cm) in the post-drainage situation indicating significant improvement in ground

water table (Fig. 4). By improving the soil conditions for water movement and also increasing drain water discharges, the performance of deep drainage systems improved. The main causes of the rise in water table are precipitation, excess irrigation, leaching water, seeps from higher land or irrigation canal and ditches and groundwater under artesian pressure that reduced by subsurface close drainage technology by removing excess groundwater from the crop root zone system which promotes safe environment for efficient crop growth that reflect on higher crop yield.

Reduction in Soil Salinity due to Closed Sub-Surface Drainage System

There was considerable reduction in soil salinity. Graph was drawn to observe the changes in ECe before and after the installation of the system (Fig. 5). Overall effect was positive and three years after installation, ECe has been reduced. Before the installation of drainage systems, ECe ranged from 6.3 to 7.1 (average: 6.7 dSm⁻¹) and after installation of drainage systems, it was observed 3.2 to 3.8 (average: 3.5 dSm⁻¹), respectively. The upper layers are reclaimed at a faster rate than the deeper layers. Within three years after installation of drainage systems, sub surface drainage technology can also be effectively used in the saline and sodic soils to remove the salts in huge quantities from the profile in shortest possible time. Establishment of sugarcane crop was good after installation of drains and general yield increase was 55 to 75%.

Conclusion

Adoption of sub-surface drainage system was found highly effective in reclamation of water logged and salt affected lands. Water table and ECe of soils were improved by 52.2 and 36.9%, respectively. Ultimately, sugarcane crop yield increased by 65.5%.

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