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RESEARCH PAPER

Effect of different spacing in conventional and controlled sub-surface drainage system on soil salinity and crops yield in saline vertisols of Tunga Bhadra Project command

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Abstract::A field Study was conducted (2017-18) to assess the performance of different spacing of conventional sub surface drainage system in comparison with controlled drainage on salinity and crop yield in saline rice fields at ARS,Gangavathi of TBP Command. Based on pre-drainage investigation and base line survey the subsurface drainage was installed in an area of 9.42 ha. The treatments consisted of conventional and controlled SSD spacing *viz.,* 40 (2.62 ha), 50 (2.8 ha) and 60 m (4.0 ha) each with a lateral depth of 1.0 m. The mean soil salinity (EC_e) in all the spacing under both conventional and controlled drainage system was reduced. The paddy grain yield varied from 33.0 to 46.0 vs. 38.0 to 52.0, 36.0 to 55.0 vs. 31.0 to 41.0 and 37.6 to 47.0 vs. 36.0 to 52.0 qha^{-1} under conventional and controlled SSD at 40, 50 and 60 m spacing respectively.

Keywords: Controlled drainage, Drain outflow, Nitrogen leaching, Spacing

Introduction

Introduction of irrigation in many arid and semiarid parts of the world including India benefitted in improving agricultural productivity. The Tunga Bhadra Project (TBP) reservoir on Tungabhadra river, a tributary of river Krishna, was commissioned in 1953 to provide protective irrigation to the drought prone areas of Northern Karnataka (3,63,000 ha) and Andhra Pradesh (1,60,000 ha). Based on soil characteristics, topographical and drainage conditions of the command area, it was proposed to allocate nearly 8 and 4 per cent of command area under paddy and sugarcane, respectively, to avoid development of waterlogged and soil salinity. Further, nearly 47 and 39 per cent of command area in *kharif* and *rabi* season, respectively, were allocated to light irrigated crops and the remaining area for garden crops in the upstream as per the report of TBP Command Area Development Authority (Anon., 2013). Though paddy area was fixed to 8 per cent (29,032 ha), actual area under paddy at present is more than 40 per cent of the command. It is also observed that paddy is being cultivated by farmers in upstream area of the command rather than in downstream as suggested in guidelines. Due to deviation in the cropping pattern, farmers in downstream areas are not only facing shortage of canal water supply for paddy crop but also the problem of secondary salinization and thus reduction in the yield levels of different crops drastically. Problems of waterlogging and soil salinity were reported in 20,200 ha in 1979-80 while it increased to 96,215 ha in 2013-14 (Anon., 2013) indicating an estimated annual loss of about 1000 ha each year. The TBP-CADA (Tunga Bhadra Project-Command Area Development Authority) has taken up surface and sub surface drainage (SSD) work in the TBP command especially in the downstream area of the command to reclaim affected soils. However, there are issues related to operation of SSD systems. The farmers in downstream area stop/ block the SSD system due to fear of water shortage during critical stages of paddy crop coupled with leaching loss of nitrate nitrogen (N). However, earlier results by (Patil *et al*., 2006) showed that blockage of outlets increased soil salinity from 2.22 to 4.1 dSm^{-1} during *rabi* and from 2.22 to 2.68 dSm^{-1} during *kharif* within two years after adoption of blockage practice. It means that blockage of the system undo benefits of SSD system. This experience suggested that SSD system should work but in controlled way.

This controlled system is known to reduce the drainage discharge while maintaining the necessary function of the drainage system. Several studies have reported positive impacts of adopting controlled drainage in arid and semi-arid regions by reducing drainage discharge and saving irrigation water (Abbott *et al.,*2001). Since the main purpose of drainage in arid and semi-arid regions is to reduce soil salinity by lowering water table for sustainable crop production, controlled drainage is however, under more scrutiny and its impact has not been fully studied (Soppe *et al.,* 2001; Ayers *et al.,* 2003; Wahba *et al.,* 2001). In a review of the potential for controlled drainage around the world, (Abbott *et al.,*2002) identified India as one of the regions that can benefit greatly from adopting controlled drainage. Ayers *et al*. (2005) reported that, from controlled drainage capillary up flow from shallow groundwater is a significant contributor of soil salinization in irrigated areas and is highly dependent on water table position and salinity. The top layer of the shallow groundwater is a dynamic zone, reflecting the interaction between the ground water, soil water and the infiltrating irrigation water. Processes occurring in this zone, such as mixing, solute transport, interactions with the soil matrix, and fluctuations in the water table may result in salinity variations over short time periods. Ghannam *et al*.(2016) reported that controlled drainage significantly reduced drainage volumes and salt loads compared to unmanaged systems. However, there were marked increases in soil salinity which will need to be carefully monitored and managed. Hornbukle *et al.* (2003) reported that, implementing controlled drainage soil salinity increased in all layers at 40, 60 and 80 cm depth of water table, higher increases were observed in the upper soil layers, particularly in the 0-30 cm and 30- 60 cm layers. Hence carefully managed controlled drainage technology is required. In view of the above, a study the effect of controlled drainage on soil salinity and crop yield in saline Vertisols of TBP Command area was planned.

Material and methods

A subsurface drainage field experiment was carried out on a 9.42 ha area at Agricultural Research Station, Gangavathi in Karnataka, India. The study was carried out during the year of 2017-18.The treatments consisted of conventional and controlled SSD spacing *viz.*, 40 (2.62 ha), 50 (2.8 ha) and 60 m (4.0 ha) each with a lateral depth of 1.0 m. These three experimental lands were divided into two equal plots to establish conventional and controlled sub surface drainage systems and each was served by three lateral drains. In both the systems, the collector drains (100 mm diameter PVC corrugated plastic pipe) were installed perpendicular to surface drain (*nala*) at 1.10 m depth and all lateral drains (PVC corrugated pipe covered by synthetic envelope materials) were installed at a depth of 1.0 m with an average spacing of about 50 m between the laterals. The slope of lateral drain was 0.1 to 0.2 % and connected to the collector drains whose slope was 0.2 to 0.3% which directly drains into *nala* through man hole.

In controlled drainage system the water table control device was made up of PVC pipe consisting of three parts (Fig.1). The first is a horizontal PVC pipe 80 mm diameter fitted onto the end of lateral drain inside the man hole and closed at the end by a PVC closing device (Karegoudar *et al*., 2019) The second part is a riser with the provision of variable height depending on the minimum water table depth required and connected with the first part. In this study controlled drainage was applied at 30 cm water table depth from the soil surface at the outlet of lateral drain during both *kharif* and *rabi* seasons of paddy. The third part is another horizontal PVC pipe (80 mm dia) connected with the riser as a lateral drain at the desired minimum water table depth. This control device was designed in such a way to restrict the drain flow by blocking the actual drain outlet as is the case in conventional SSD system.

Rice was transplanted in *kharif* -17 (BPT 5204) season in these experimental sites. The paddy crop was transplanted in August and January and harvested in December season. Except the control device, agronomic practices followed for paddy were similar in both the systems. The soil samples were collected to a depth of 90 cm with 15 cm increment were taken from both conventional and controlled plots in zigzag position using GPS and analyzed for initial soil pH and soil salinity (EC, dSm^{-1}) on a 1:2.5 soil water suspension and the EC so obtained was converted to ECe (dSm^{-1}) *i.e.,* EC of saturation paste extract by multiplying EC with a conversion factor 2.66 which was worked out for these soils at ARS, Gangavathi. Soil samples to a depth of 90 cm were also collected at the end of each cropping season and analyzed for soil salinity appraisal.

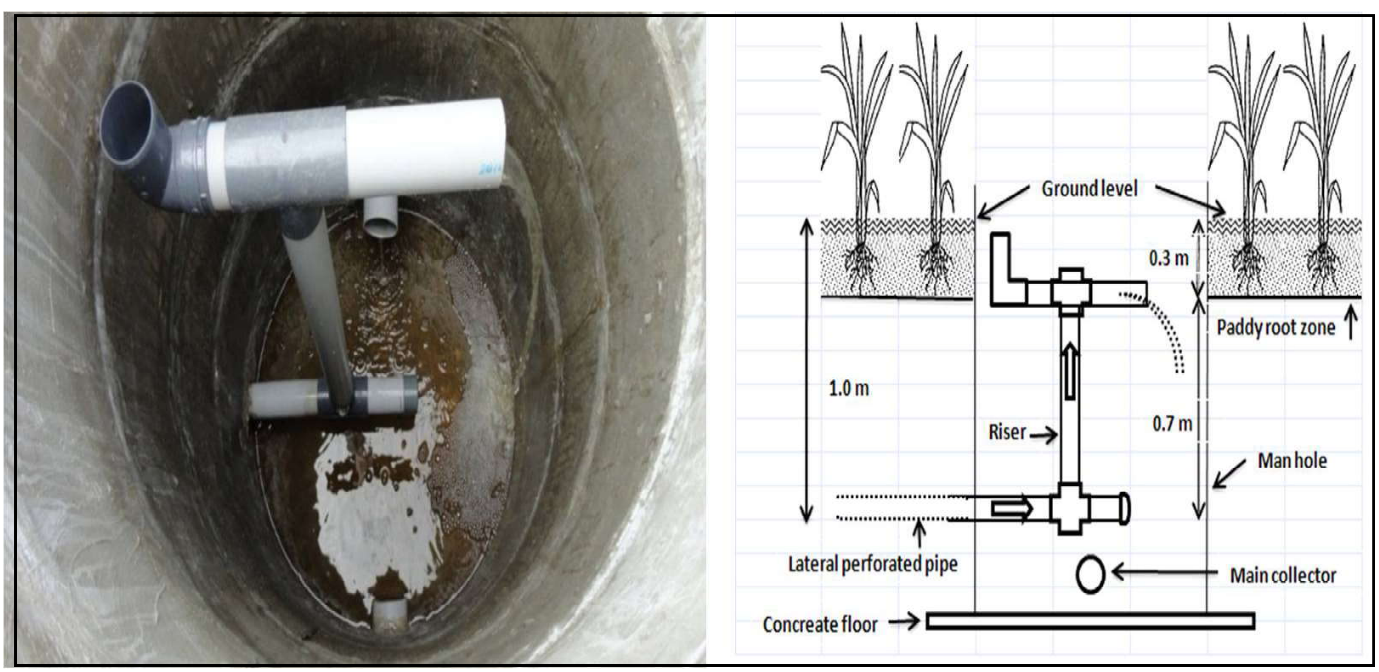

Fig 1. Indigenously developed water table control device installed in manhole (Adopted from: M.A.S.Wahba *et al.*, 2001)

Table 1. Changes in soil salinity (EC_e dSm^{-1}) over cropping season under different spacing of conventional and controlled SSD

Season	40 m spacing							
	Conventional drainage (cm)				Controlled drainage (cm)			
	0-15	15-30	30-60	60-90	0-15	15-30	30-60	60-90
Initial	8.05	8.66	9.70	9.94	7.34	8.15	8.63	9.18
Kharif-17	3.56	4.35	4.63	4.73	1.88	4.15	4.54	4.90
	50 m spacing							
Initial	4.30	5.09	5.91	5.26	6.30	8.29	12.00	13.85
Kharif-17	1.43	1.44	2.08	3.15	1.90	3.54	4.13	5.57
	60 m spacing							
Initial	3.06	3.83	7.21	8.79	5.99	6.29	6.42	6.11
Kharif-17	3.05	3.82	5.52	6.3	3.34	3.36	4.33	6.10

Results and discussion

Soil salinity

The mean soil salinity under 40 m spacing under conventional SSD during *kharif*-17 reduced from 8.05 to 3.56 at 0-15cm, from 8.66 to 4.35 at 15-30 cm, from 9.70 to 4.63 at 30-60 cm and from 9.94 to 4.73 dSm^{-1} at 60-90 cm, respectively (Table.1). In case of controlled drainage system, the average soil salinity reduced from 7.34 to 1.88 dSm^{-1} at 0-15 cm, from 8.15 to 4.15 dSm^{-1} at 15-30 cm and salinity increased from 8.63 to 4.54 dSm^{-1} at 30-60 cm and from 9.18 to 4.90 dSm^{-1} at 60-90 cm, respectively. The mean soil salinity under 50 m spacing under conventional SSD during *kharif*-17 reduced from 4.30 to 1.43 at 0-15cm, from 5.09 to 1.44 at 15-30 cm, from 5.91 to 2.08 at 30-60 cm and from 5.26 to 3.15 dSm^{-1} at 60-90 cm, respectively. In case of controlled drainage system, the average soil salinity reduced from 6.30 to 1.90 dSm^{-1} at 0-15 cm, from 8.29 to 3.54 dSm^{-1} at 15-30 cm, from 12.0 to 4.13 dSm^{-1} at 30-60 cm and from 13.85 to 5.57 dSm^{-1} at 60-90 cm, respectively. The mean soil salinity under 60 m spacing under conventional SSD during *kharif*-17 reduced from 3.06 to 3.05 at 0-15cm, from 3.83 to 3.82 at 15-30 cm, from 7.21 to 5.52 at 30-60 cm and from 8.79 to 6.3 dSm^{-1} at 60-90 cm, respectively. In case of controlled drainage system, the average soil salinity reduced from 5.99 to 3.34 dSm^{-1} at 0-15 cm, from 6.29 to 3.36 dSm^{-1} at 15-30 cm, from 6.42 to 4.33 dSm^{-1} at 30-60 cm and from 6.11 to 6.10 dSm^{-1} at 60-90 cm, respectively. Results of the study indicated that, irrespective of the spacing, with continuous flow of drain water removal of dissolved salts through drainage effluent was faster as well as from deeper depth in conventional drainage than controlled drainage system.

Table 2. Variation of paddy grain yield (qha^{-1}) as influenced by spacing of SSD and controlled drainage systems

Season	Conventional sub surface drainage			Controlled sub surface drainage		
	40 m	50 m	60 m	40 m	50 m	60 m
Initial	33.0	38.0	36.0	31.0	37.6	36.0
Kharif-17	46.5	52.0	53.4	42.0	45.3	49.4

Grain yield

During *kharif*-17 paddy grain yields were 46.5 vs. 42.0, 52.0 vs. 45.3 and 53.4 vs. 49.4 qha^{-1} under conventional and controlled drainage systems at 40, 50 and 60 m SSD spacing, respectively (Table 2).

Conclusion

The rate of reclamation of waterlogged saline land was faster in case of conventional drainage compared to controlled drainage. The continuous flow of drain water removal of dissolved salts through drainage effluent was faster as well as from deeper depth in conventional drainage than controlled drainage system. Hence, mean soil salinity (EC_e) in all the spacing under both conventional and controlled drainage system was reduced. The paddy grain yield improvement was slightly higher (from 13.5 to 17.4 qha^{-1}) for conventional compared to controlled drainage conditions (from 7.7 to 13.4 qha^{-1}) at 40 to 60 m spacing, respectively.

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