

1 **PERFORMANCE EVALUATION OF SUBSURFACE DRAINAGE**
2 **SYSTEM WITH REFERENCE TO WATER TABLE RESPONSE IN**
3 **ADUTHURAI, TAMIL NADU, INDIA**

4 *Punitha,M¹. and Rajendran,R².*

5 ¹Ph.D. Student, AEC&RI, Department of Land and Water Management Engineering

6 ²Professor, AEC&RI, Department of Land and Water Management Engineering

7 Tamil Nadu Agricultural University, Kumlur, Trichy, India

8 Corresponding Author:* puni.dec20@gmail.com

9 Keywords: (Waterlogging, Sub surface drainage, Drainage Coefficient, Water table depth)

0 Abstract

Water logging and subsequent soil salinity are the two major effects of irrigated agricultural lands. Low lying areas are susceptible to water logging. Subsurface drainage is an effective control measure for salinity removal and waterlogging. Subsurface drainage pipes were installed in 0.95 hectare area respectively in Tamil Nadu Rice Research Institute, Aduthurai. Drain pipes with different spacing of 7.5, 10 and 12.5 m with drain depth of 60 and 80 cm having drain diameter of 63 and 75 mm were installed by using two drain lateral lengths of 15 and 20 m were installed to combat the problem of water logging. Analysis of data collected on discharge from individual pipe drains revealed that the maximum. The maximum 0.4 m reduction of groundwater table during the crop period of the experiment achieved in 7.5 m drain spacing whereas, it was minimum in 10 cm and 12.5 m drain spacing. Spacing of 7.5 m and depth of 80 cm was recommended to achieve better performance in study area to alleviate waterlogged condition.

3 Introduction

Studies conducted at Krishna western Delta estimated that an area of about 8.4 million ha is affected by soil salinity and alkalinity in India out of which 5.5 million ha land affected by waterlogged saline area (Srinivasulu et al.2006). The function of subsurface drainage system is to eliminate surplus water from the land (Ogino and Ota 2007). (Deelstra et al., 2005) Subsurface drainage system was installed at a depth of 1.75 m with three different drain spacing (25, 50 and

75 m). The drain facilitated the reclamation of the waterlogged saline land which had variations in salt removal with space and time. A well designed subsurface drainage system with effective drain spacing and depth contributes large ratio of water logging and crop yield. To identify the optimization design, subsurface drainage performance should be identified based on water table fluctuations and crop yield. One of the most important factors for appropriate performance of subsurface drainage systems is having adequate discharge for drains. (Luan and Leng .,2008) compared monotonic behaviors of granular soils under different drainage conditions. Properties of soil are an important parameter to allow the desired flow. If the permeability of the soil is really slow, the tile drainage lines in the system can be spaced closer together (Wood Country Soil Survey 2000). Rapid change in the subsurface drain flows has been mainly occurred during the month of January.

The purpose of subsurface drainage in a paddy field is to remove the excess water in the surface soil and remaining water on the soil surface (Ogino and Ota., 2007). The drainage system was installed before start of the monsoon period. Design based on steady state condition of flow to the drains. Water flow at the midway between above the drains was taken as radial flow zone. Spacing of drains had more effect on drainage rate. Research on the effect of openings in drainpipes was stimulated by the introduction of plastic drains in the United States. Widmoser ,1968 studied the effect of circumferential openings on drain performance and also effective drain radius , the drain diameter on the entrance resistance of the drainage materials. Therefore smaller the entrance resistance is larger the effective radius would be. Potential of nitrate leaching in drainage water is high because it is easily susceptible for leaching towards the drain pipe by water flow rapidly. (Algoazany et.al., 2007). Meenakshi Hirekhan reported that study was conducted at Haryana to assess the effect of annual rainfall and drainage intensity, due to varying drain spacing on the groundwater table behavior and the resulting excess water index calculated. The results revealed that a rapid rise in the water table due to of rainfall reaching the soil surface at least once in a year in the case of 75 and 50 m drain spacing while in the case of 25 m it remained below 0.3 m of the soil surface throughout. The drain spacing mainly influenced the haste of water table fall based on the cessation of rainfall. Drainage design associated with placing the drains at different depth or spacing would change the drainage intensity This study aimed to assess the feasibility of subsurface drainage for reduction of groundwater table during waterlogged condition.

Materials and methods

Study area

An Experiment was conducted at the Tamil Nadu Rice Research Institute, Aduthurai. The study area located at 11°00' 55" N latitude, 79° 28' 51" E longitude and at an altitude of 25 m above mean sea level. The soil of the study area site is clay loam with bulk density of 1.5 g cc⁻¹. The hydraulic conductivity of the soil is 0.21m day⁻¹. The average annual rainfall of the study area is 1400 mm out of which 75 percent occurs in the rainy season from October to January. Pre investigation of the groundwater table in the experimental site is measured to be varied from 2 cm during rainy season. Cultivation of dry crops during summer is also not possible because of the shallow groundwater table. Even during the peak of the rainy season, where there is continuous period of heavy rainfall the area remains inundated because of lack of proper drainage facility Thereby causing submergence of rice crop and hence affecting the yield severely.

Experimental details

Table.1 Details of the Treatments Employed for the Experiment

L ₁	Length of drain	15 m
L ₂	Length of drain	20 m
S ₁	Spacing between drain	7.5 m
S ₂	Spacing between drain	10 m
S ₃	Spacing between drain	12.5 m
T ₁	Depth of drain + diameter of drain	60 cm and 63 mm
T ₂	Depth of drain + diameter of drain	60 cm and 75 mm
T ₃	Depth of drain + diameter of drain	80 cm and 63 mm
T ₄	Depth of drain + diameter of drain	80 cm and 75 mm

76 **Layout of Subsurface drainage system**

77 The experiment was undertaken in the field at North farm, block b1a. For the
78 experimental field, Length of 108 m and width of 77 m were taken. Field was divided in to two
79 plots with different length and each plot has been subdivided in to 3 plots with different drain
80 spacing. In case of all the three drain spacing, the excess water as well as seepage water from
81 each plot was drained out by the collector drains and then conveyed to the lateral drain.

82 Lateral drains were connected to the main drain that collected water and finally disposed
83 in to a farm pond. Inspection chamber were installed at the end of the collector drain for sample
84 collection. Every depth of drain pipe was separated by buffer pipes. The slope of the drain was
85 0.3 %. Observation wells of drilled PVC pipe have been installed at the midway between drains
86 to monitor the depth of groundwater table.

87 Spacing and depth of drains were separated by means of buffer pipe. Length of drain
88 probably considered for reducing the clogging problem. In high saline areas length will also an
89 influencing parameter. In split split plot experimental design, main parameters were considered
90 for split plot and very less influencing parameter were considered in main plot.



Fig.1. Installation of drain pipe

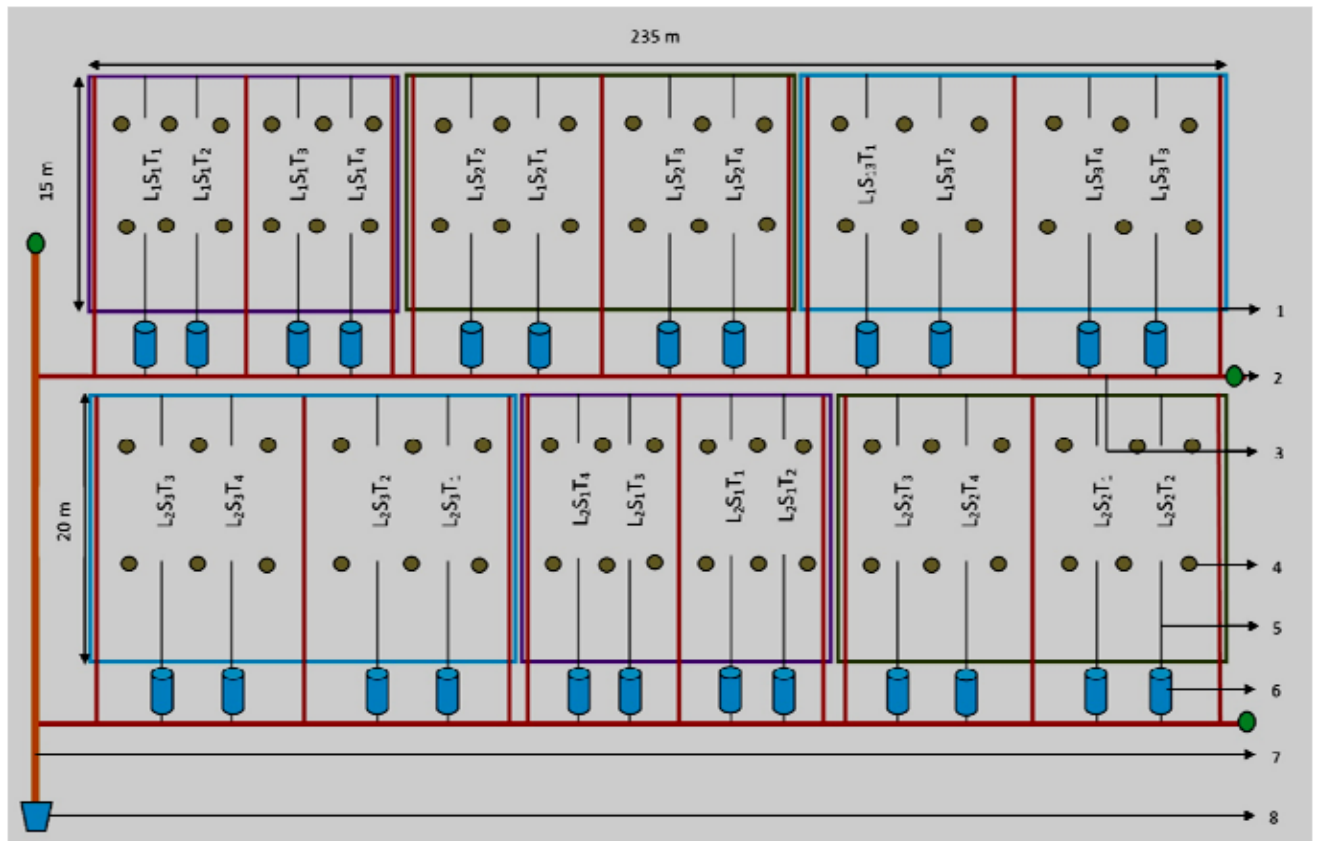


Fig.2. Layout of subsurface drainage system experimental plot with different treatments

1. Split plot
2. End cap
3. Buffer pipe
4. Observation well
5. Collector drain
6. Inspection chamber
7. Main drain pipe
8. Farm pond

All steady state subsurface drainage equations were developed mostly based on flow pattern in ordinary field condition. One of the well known drainage equations for calculating parallel drain spacing is Hooghoudt's equation. Hooghoudt's (1940) equation was used to express the relation between head loss and discharge for each of the plots.

$$S^2 = \frac{4K_a h_w^2}{q} + \frac{8K_b d h_w}{q} \dots\dots\dots (1)$$

K_a = Hydraulic conductivity above drain level, m/day

K_b = Hydraulic conductivity below drain level, m/day

h_w = Head of water midway between drains, m

q = Design drainage rate, m/day

d = Hooghoudt's equivalent depth, m

S = Drain spacing, m²

For planning and design of subsurface drainage in paddy fields, understanding of flow pattern near drain pipe is necessary. Hooghoudt's equation is mainly based on the assumption of flow is radial near the drains because of the curvature nature of drain flow and the Dupuit Forcheimer assumptions showed that flow in the region is always away from the drains.

Results and discussions

Drainage coefficient

In the steady state analysis, the effects of drain depths and spacings on drainage coefficient were considered. The Measurements of drainage coefficient in the study area revealed that 7.5 m drain spacing with drain depth of 80 cm can quickly dispose of the excess water from the waterlogged area by means of higher drainage coefficient value $5.9 \text{ m}^3 \text{ day}^{-1} \text{ ha}^{-1}$ whereas that for 7.5 m spacing and depth 80 cm.

Depth to water table

The spacing between the drains was influenced by the drain characteristics. The field has been intensively monitored by using observation wells were installed in midway between the drains. This paper evaluated the subsurface drainage system mainly based on reduction in water table depth. Flow towards the drain pipe influenced by hydraulic conductivity, equivalent depth and impervious stratum.

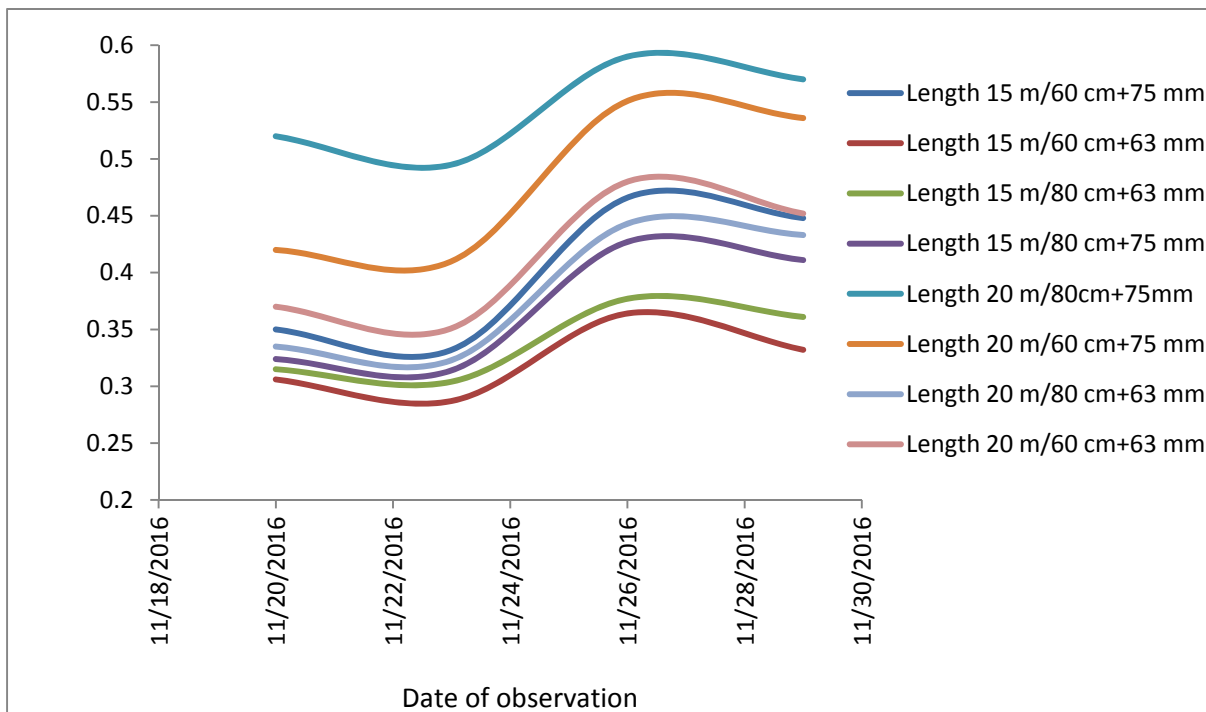
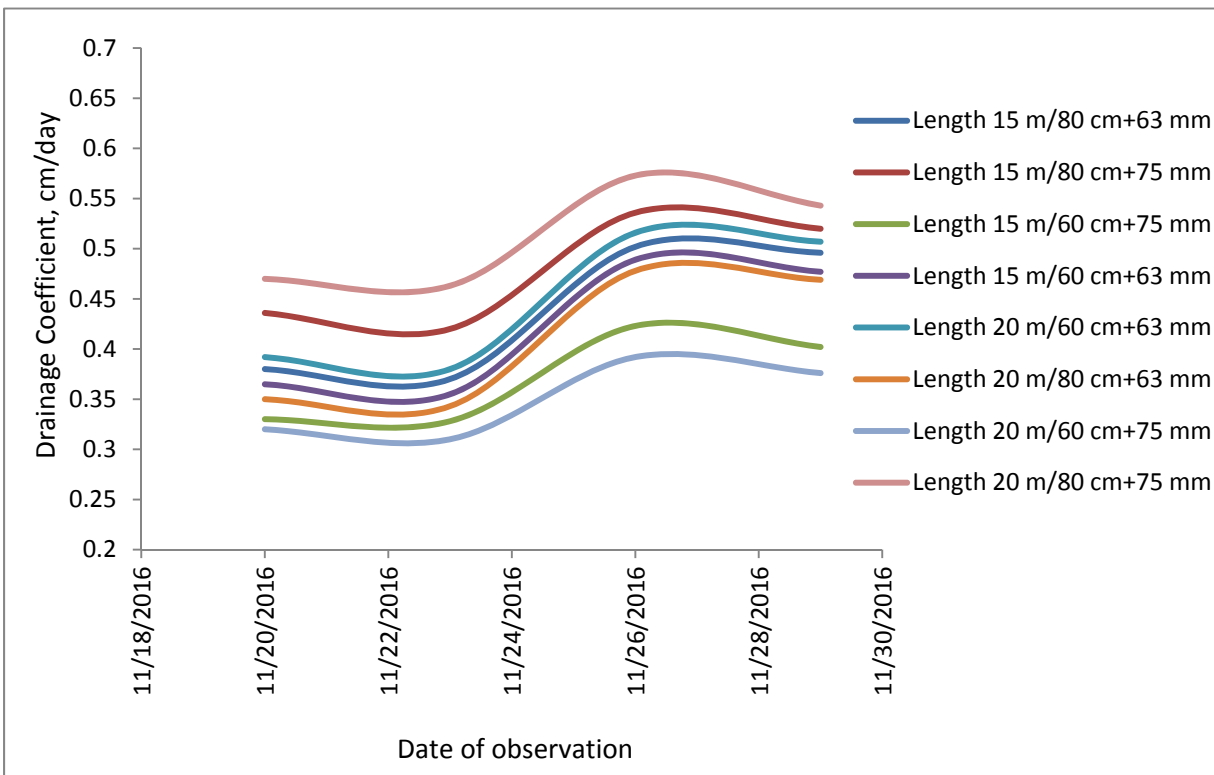


Fig.3. Observed drainage coefficient with drain spacing of 7.5 m

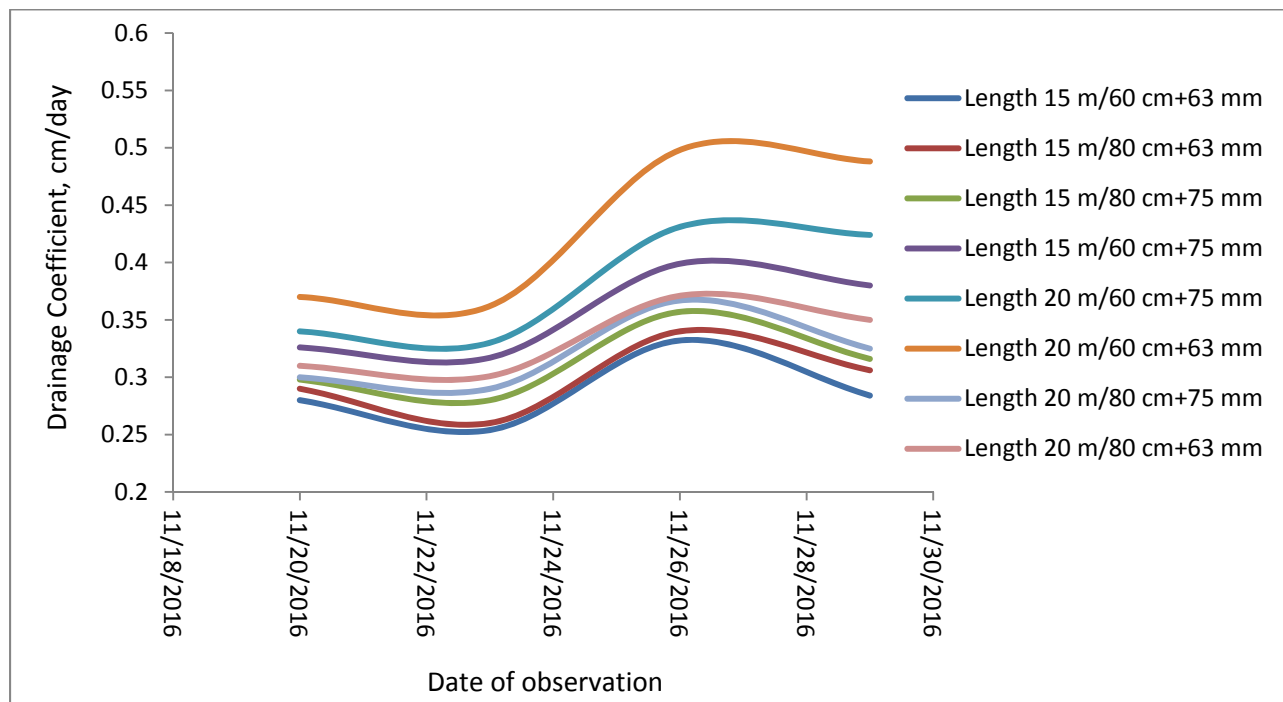
125



126

127

Fig.4. Observed drainage coefficient with drain spacing of 10 m



128

129

Fig.5. Observed drainage coefficient with drain spacing of 12.5 m

The fluctuations of the ground water table in the study area for different drain spacing drain depth and drain length were presented in fig.6, 7, 8. It has been observed that maximum reduction of groundwater table occurred in 7.5 m drain spacing ranging from 0.4 to 0.1 m below ground level whereas the minimum reduction of groundwater table occurred in 12.5 m drain spacing ranging from 0.2 m to 0.4 m. It is to mention here that the groundwater table before the starting of the experiment was shallow. Thus, opening of the drains has positive effect on lowering the water table. Hence, the trend of reduction in water table indicates that the reclamation of waterlogged area by subsurface drainage system.

The cumulative amount of salts added through irrigation and fertilizers and the salts discharge through the drainage system will be predicted. The trend of root zone salinity decreased considerably due to proper functioning of the drainage system. Some amount of salts will be deposited beneath the root zone layer during leaching of salts and it will be transported to the above layer, because of capillary action. The amount of salts added during this period would be removed by drainage system.

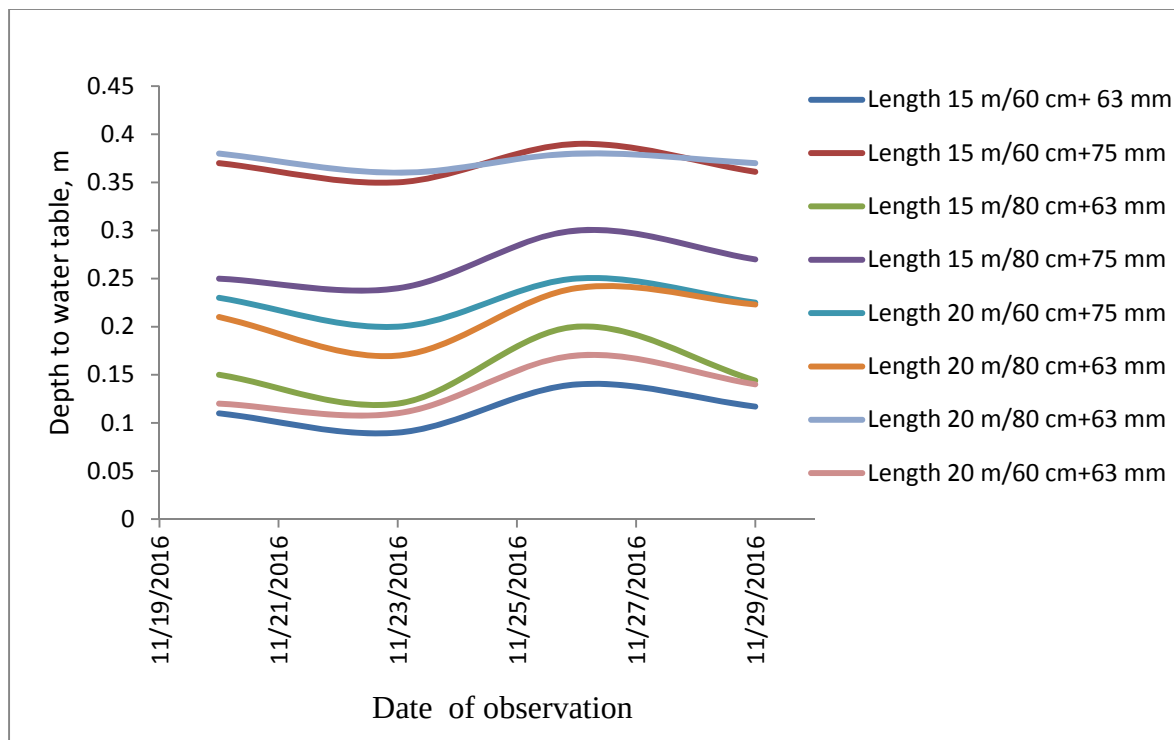


Fig.6. Depth to water table with drain spacing of 7.5 m

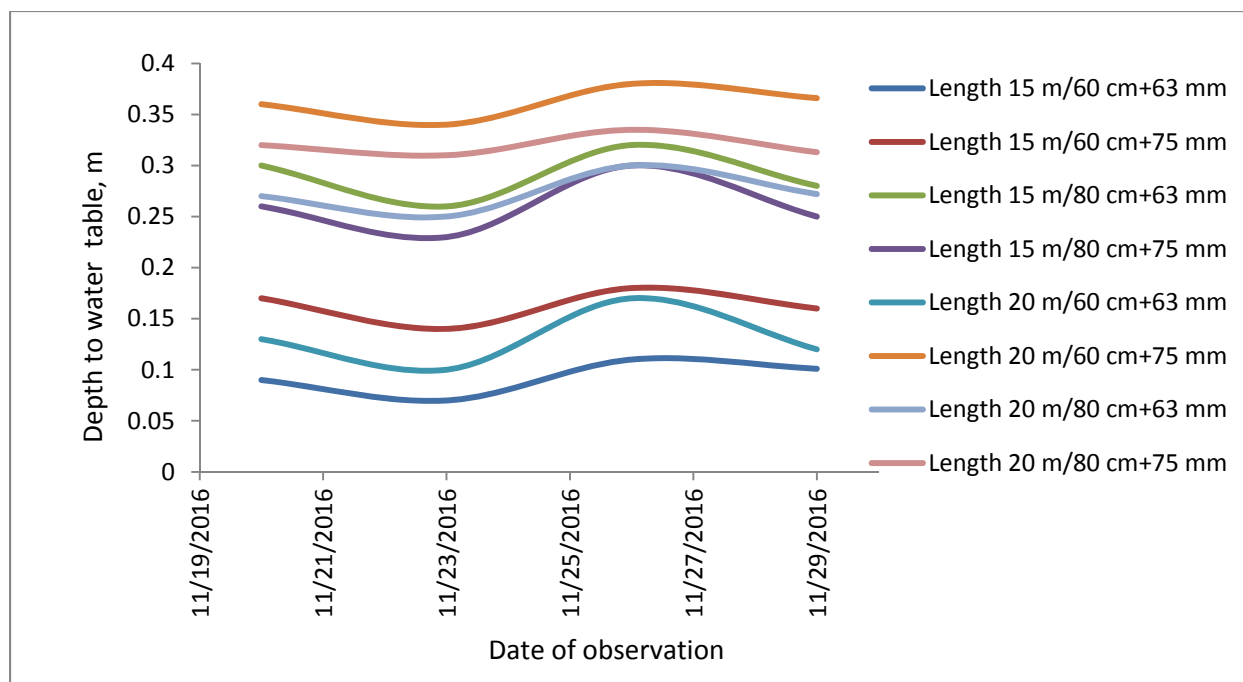


Fig.7. Depth to water table with drain spacing of 10 m

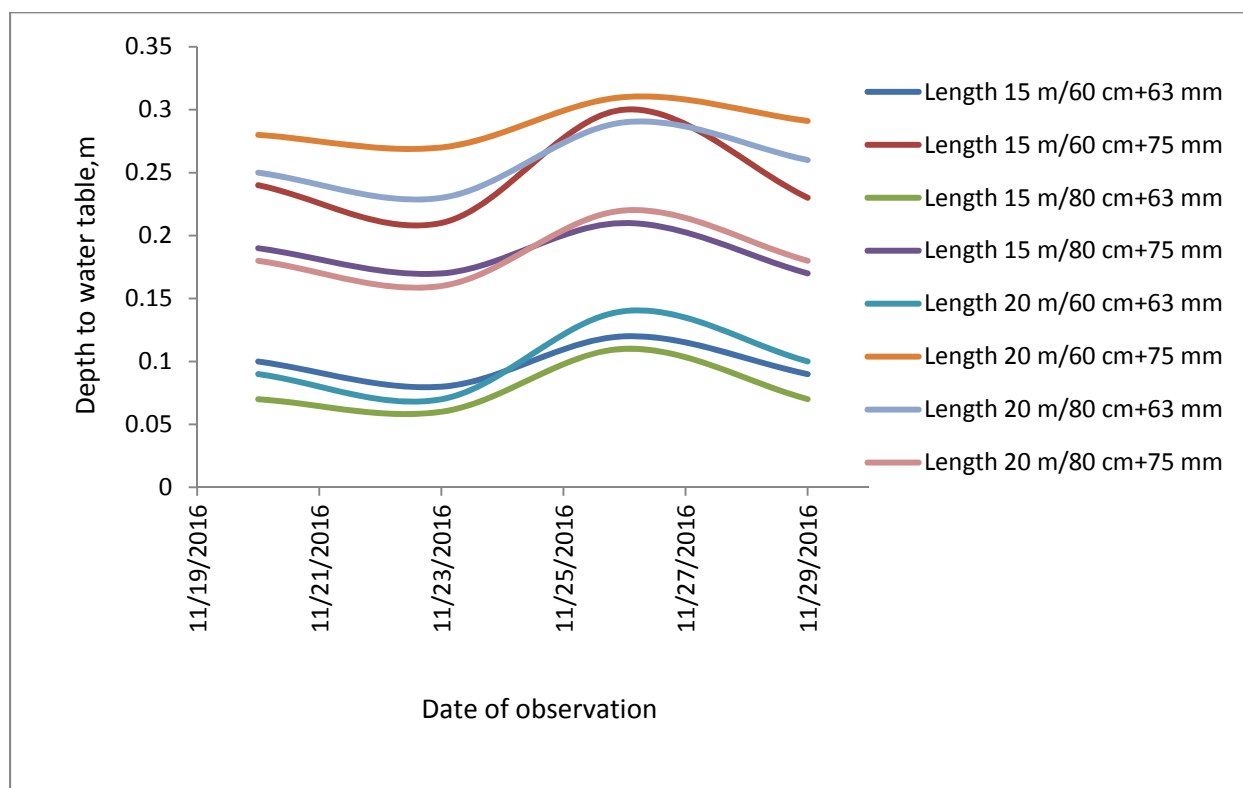


Fig.8. Depth to water table depth with drain spacing of 12.5 m

5. Conclusion

The study has demonstrated that subsurface drainage was significant in water removal and also had remarkable influences in crop yield. Evaluated subsurface drainage system according to four main evaluation indexes (spacing, length, depth and diameter of drain pipes) and the calculation results proved that drain spacing of 7.5 m and drain depth of 80 cm were more beneficial to improve soil conditions and promoted the aeration in the root zone of the crop. Narrow spacing of drains was more beneficial when compared to wider spacing of drains. Use of shallow drains may remove water from above the root zone of crop and it will affect the root zone penetration.

Envelope material such as coir pith provided environmental benefits as well as economic benefits instead of using geo materials. Optimal design of subsurface drainage system is recommended for amelioration of water logging.

References

Algoazany,A.S., Kalita,P.K.,Czapar,G.F.,Mitchell,J.K.,2007. Phosphorus transport through subsurface drainage and surface runoff from a flat watershed in east central Illinois, USA . Journa of Environment Quality, 2007, 36 (3), 681- 693.

Deelstra, J., Abramenko, K., Vagstad, N., Jansons, V. 2005. Scale issues, hydrological pathways, and nitrogen runoff from agriculture -results from the Mellupite catchment, Latvia. Proceedings of the 3rd International SWAT Conference; 2005 Jul 11–15Swiss Federal Institute of Aquatic Science and Technology.

Hooghoudt, S. B., 1940. General consideration of the problem of field drainage by parallel drains, ditches, watercourses and channels. Publication No.7 in the series contribution to the knowledge of some physical parameters of the soil. Bodemkundig institute, Groningen

Meenakshi Hirekhan, S.K.Gupta and K.L.Mishra.2007. Application of WaSim to assess performance of a subsurface drainage system under semi-arid monsoon climate

Ogino Y, Ota,S.,(2007). The evolutions of Japan's rice field drainage and development of technology. Irr. Drain. 56(I):69-80

179 Luan M. and Y. Leng 2008. A Comparative Study on Monotonic Shear Behaviors of
180 Granular Soils under Different Drainage Conditions, Geotechnical Engineering for Disaster
181 Mitigation and Rehabilitation pp.1068-1078

182 Srinivasulu.A.,T.V.Satyanarayana, M.Raghu Babu and H.V.Hema Kumar,2006.
183 Performance evaluation of drainage sytems in waterlogged coastal sandy clay loam soil at a pilot
184 area in Krishna Western Delta. J.agrl.engg. Vol.43(1)

185

186

187