

1 **PERFORMANCE EVALUATION OF SUBSURFACE DRAINAGE** 2 **SYSTEM WITH REFERENCE TO WATER TABLE RESPONSE**

3 Keywords: (Water logged, Sub surface drainage, Drainage Coefficient, Water table depth

4 **Abstract**

5 Water logging and subsequent soil salinity are the two major causes of irrigated
6 agricultural lands. Low lying areas are susceptible to water logging (Manjunatha and Oosterbaan
7 2004). Subsurface drainage is an effective control measure for both. Subsurface drainage pipes
8 were installed in 0.95 hectare area respectively in Tamil Nadu Rice Research Institute,
9 Aduthurai. Drain pipes with different spacing of 7.5, 10 and 12.5 m with drain depth of 60 and
10 80 cm having drain diameter of 63 and 75 mm were installed by using two drain lateral lengths
11 of 15 and 20 m were installed to combat the problem of water logging. Analysis of data collected
12 on discharge from individual pipe drains revealed. The maximum 0.4 m reduction of
13 groundwater table during the crop period of the experiment achieved in 7.5 m drain spacing
14 whereas, it was minimum in 10 cm and 12.5 m drain spacing.

15 **Introduction**

16 Studies conducted at Krishna western Delta estimated that an area of about 8.4 million ha
17 is affected by soil salinity and alkalinity in India out of which 5.5 million ha land affected by
18 waterlogged saline area (Srinivasulu et al.2006). The function of subsurface drainage system is
19 to eliminate surplus water from the land (Ogino and Ota 2007). A well designed subsurface
20 drainage system with effective drain spacing and depth contributes large ratio of water logging
21 and crop yield. To identify the optimization design, subsurface drainage performance should be
22 identified based on water table fluctuations and crop yield. One of the most important factors for
23 appropriate performance of subsurface drainage systems is having adequate discharge for drains.
24 (Luan and Leng 2008) compared monotonic behaviors of granular soils under different drainage
25 conditions. Properties of soil are an important parameter to allow the desired flow. Rapid change
26 in the subsurface drain flows has been mainly occurred during the month of January.

27 The purpose of subsurface drainage in a paddy field is to remove the excess water in the
28 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. Potential of nitrate leaching in drainage water is high because it is easily susceptible for leaching towards the drain pipe by water flow rapidly. This study aimed to assess the feasibility of subsurface drainage for reduction of groundwater table during waterlogged condition.

Materials and methods

Study area

Experiment was conducted at the Tamil Nadu Rice Research Institute, Aduthurai. The study area is lies at 11°00' 55" N latitude, 79° 28' 51" E longitude and 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 peaky 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

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

49

50 **Layout of Subsurface drainage system**

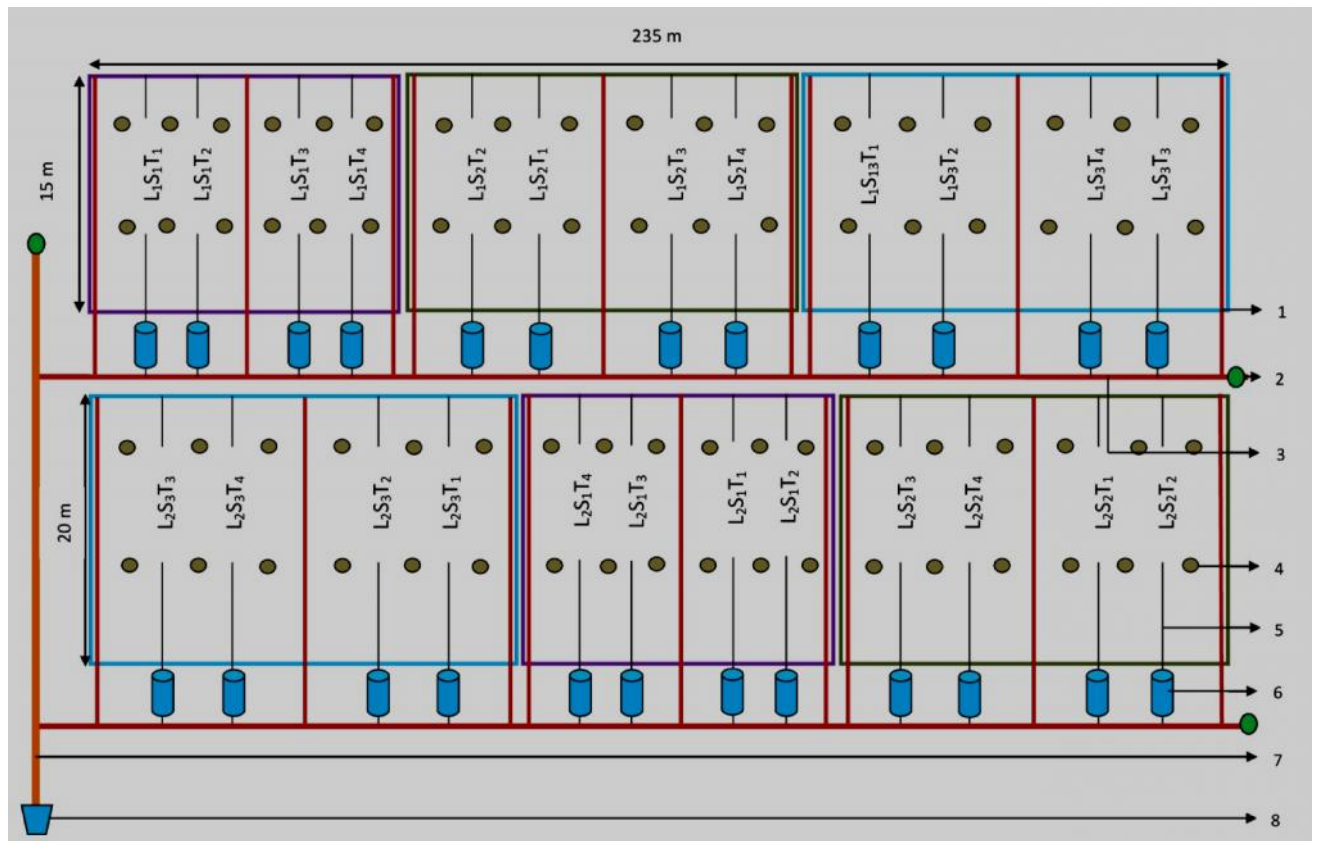
51 The experiment was undertaken in the field at North farm, block b1a. For the
52 experimental field, Length of 108 m and width of 77 m were taken. Field was divided in to two
53 plots with different length and each plot has been subdivided in to 3 plots with different drain
54 spacing. In case of all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

56 Lateral drains were connected to the main drain that collected water and finally disposed
57 in to a farm pond. Inspection chamber were installed at the end of the collector drain for sample
58 collection. Every depth of drain pipe was separated by buffer pipes. The slope of the drain was
59 0.3 %. Observation wells of drilled PVC pipe have been installed at the midway between drains
60 to monitor the depth of groundwater table.

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



Fig.1. Installation of drain pipe



65

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

- 66 1. Split plot
- 67 2. End cap
- 68 3. Buffer pipe
- 69 4. Observation well
- 70 5. Collector drain
- 71 6. Inspection chamber
- 72 7. Main drain pipe
- 73 8. Farm pond

74

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

$$79 \quad S^2 = \frac{4K_a h_w^2}{q} + \frac{8K_b d h_w}{q} \dots\dots\dots (1)$$

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

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

84 Result and discussions

85 In the steady state analysis, the effects of drain depths and spacings on drainage
 86 coefficient were considered. Measurement of drainage coefficient in the study area reveals that
 87 7.5 m drain spacing with drain depth of 80 cm has can quickly dispose of the excess water from
 88 the waterlogged area by means of higher drainage coefficient value $5.9 \text{ m}^3 \text{ day}^{-1} \text{ ha}^{-1}$ whereas that
 89 for 7.5 m spacing and depth 80 cm.

90 Depth to water table

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

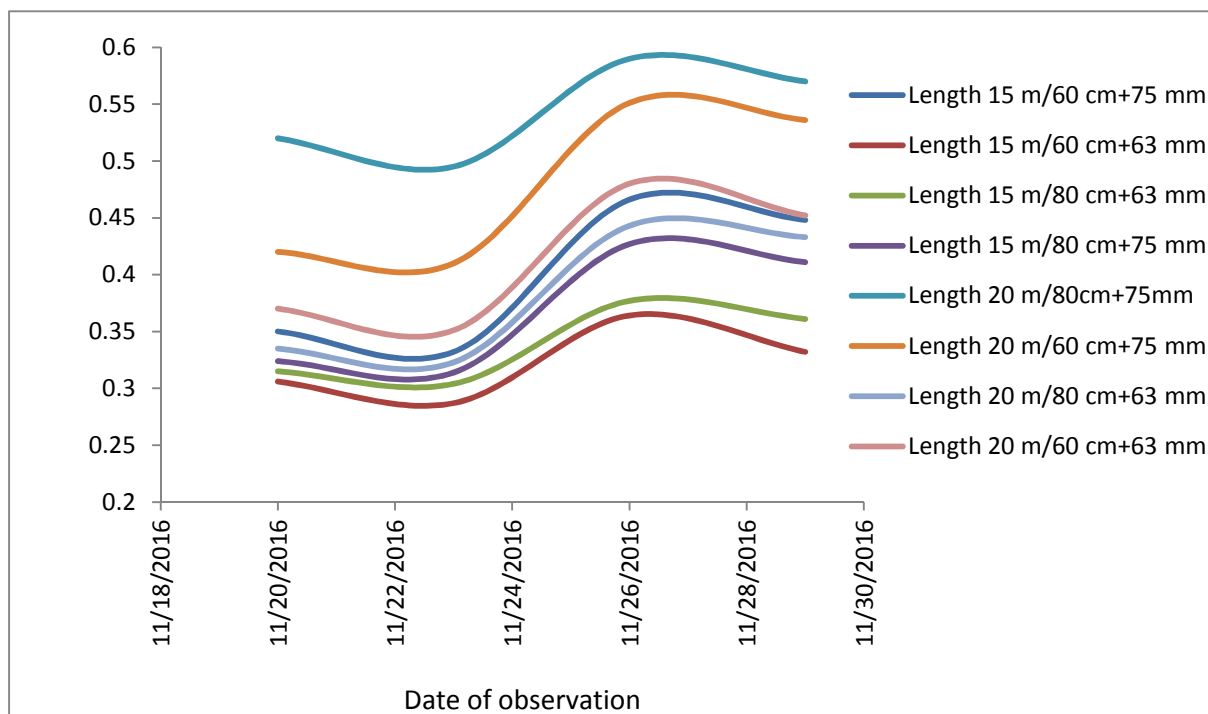
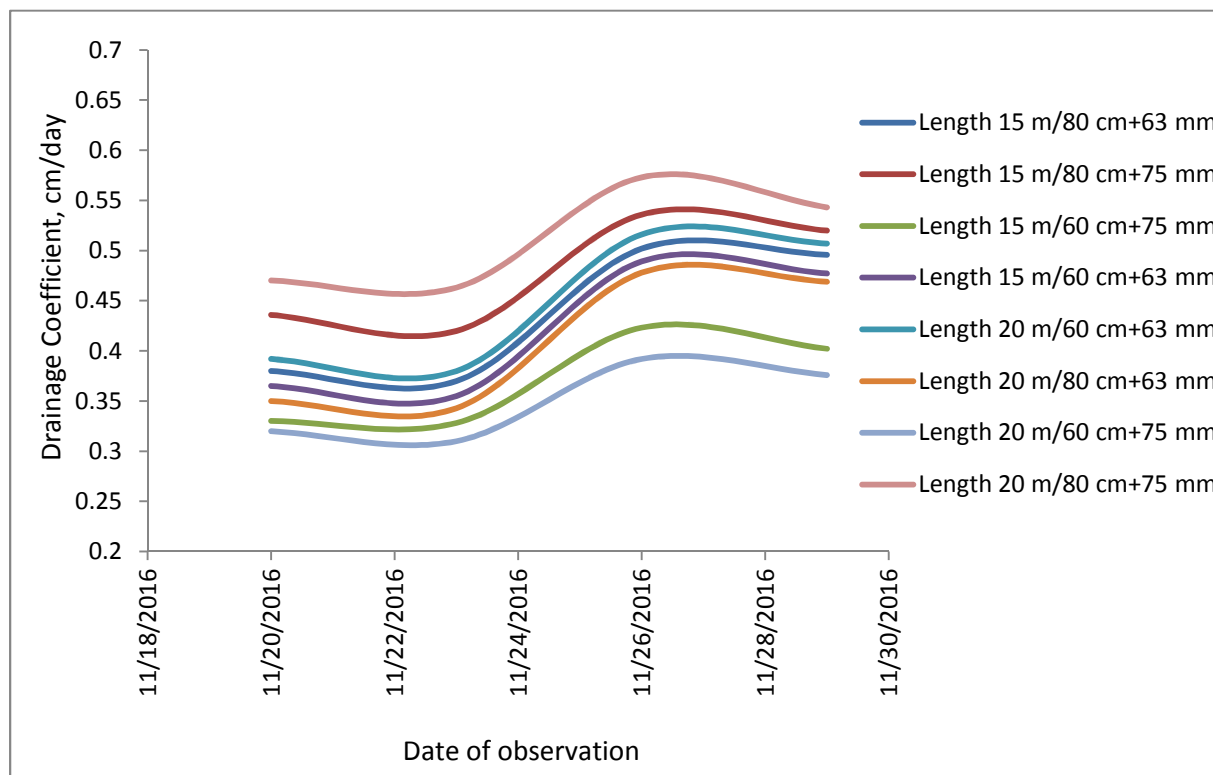


Fig.3. Observed drainage coefficient with drain spacing of 7.5 m

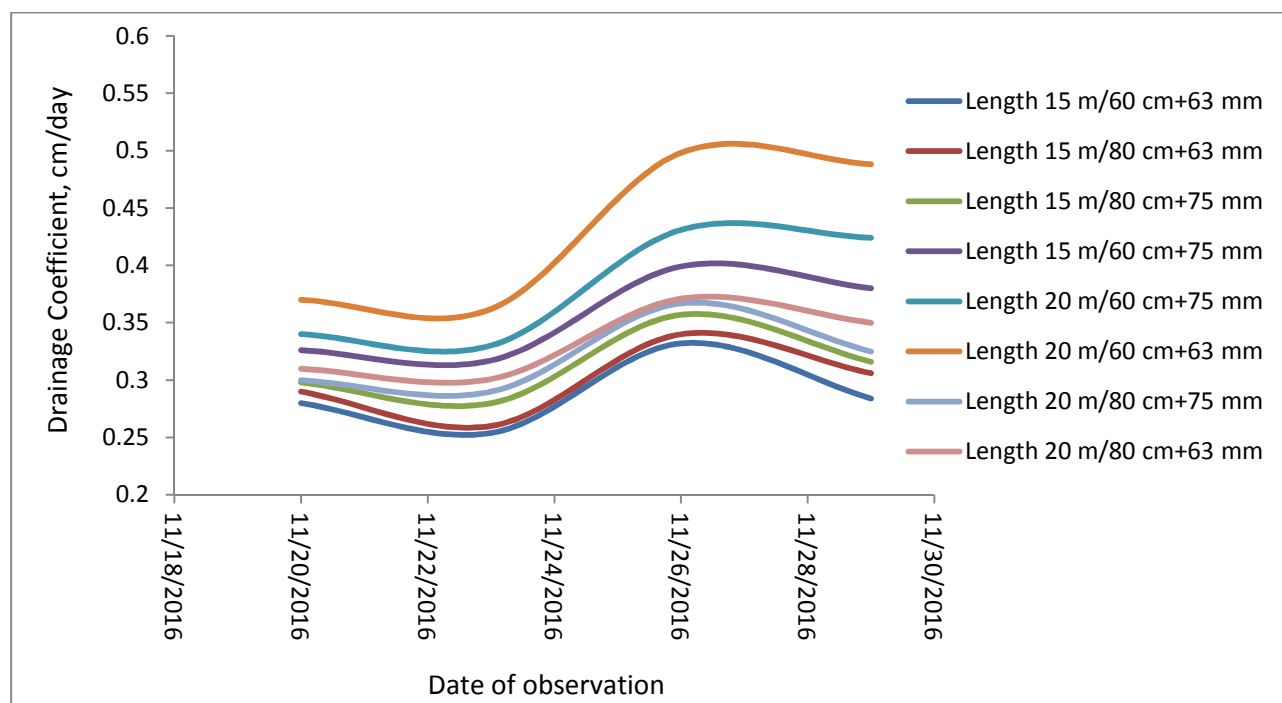
98



99

100

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



101

102

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.

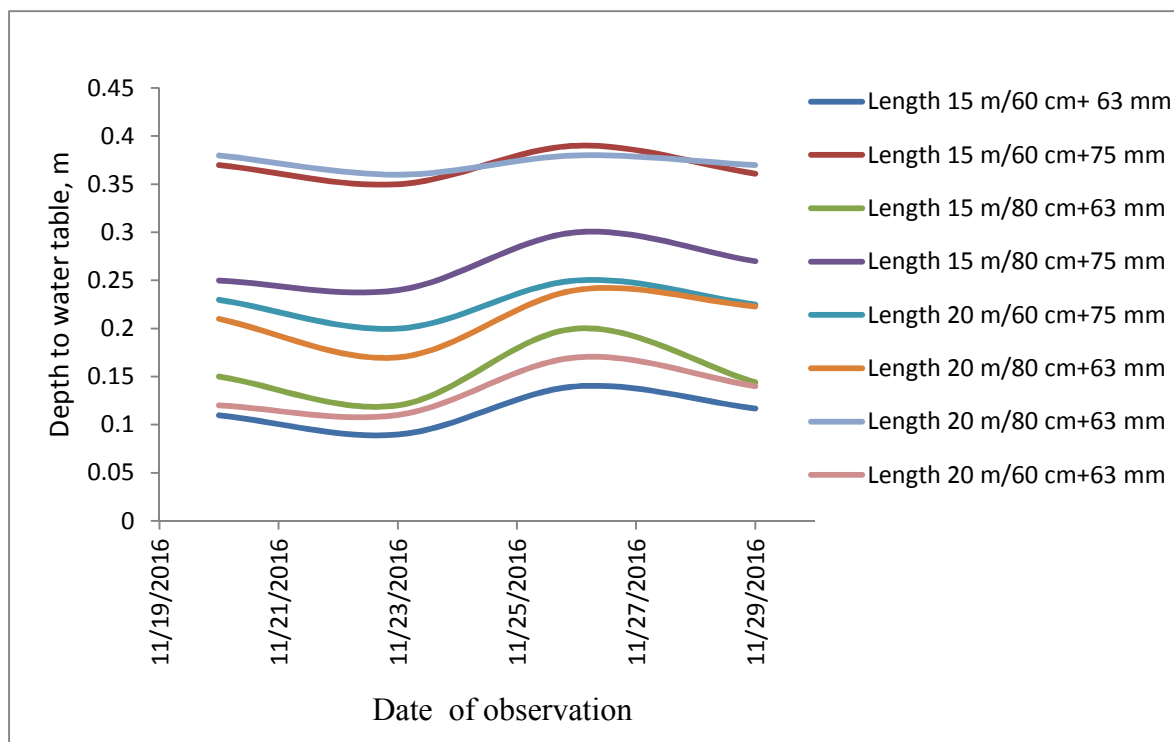


Fig.6. Depth to water table with drain spacing of 7.5 m

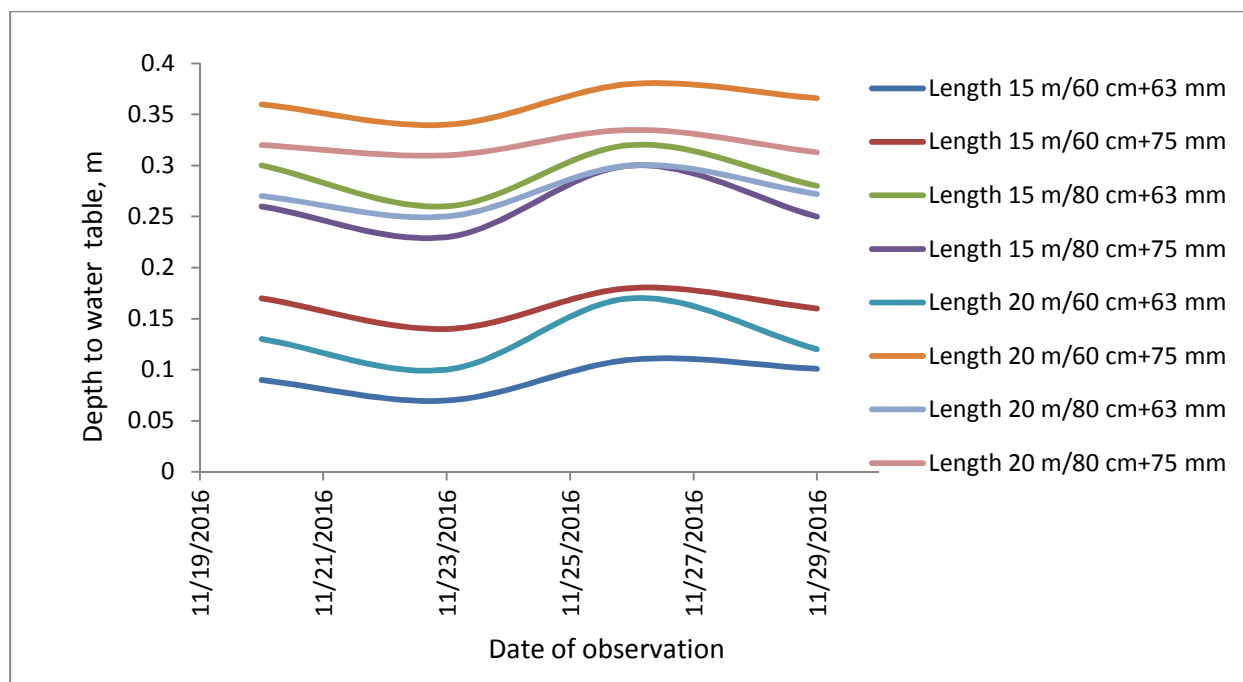


Fig.7. Depth to water table with drain spacing of 10 m

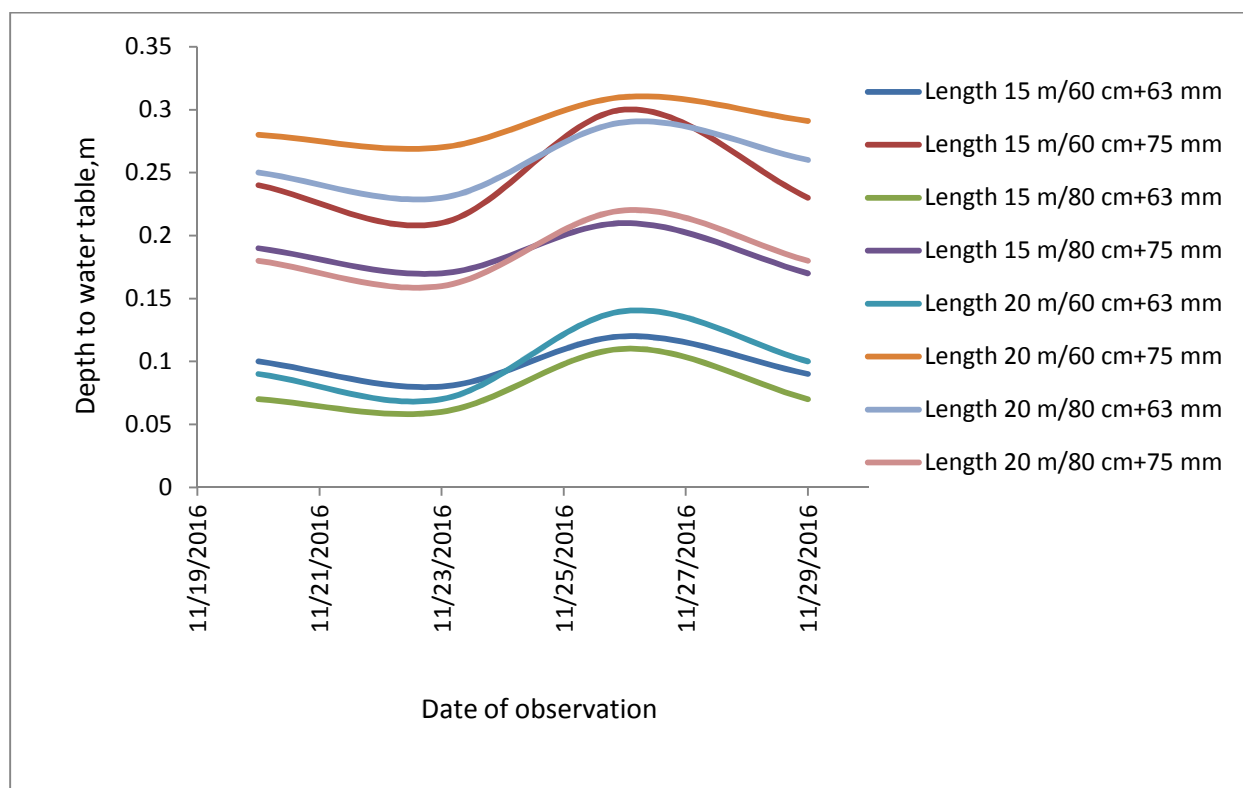


Fig.8. Depth to water table depth with drain spacing of 12.5 m

5. Conclusion

It was demonstrated that subsurface drainage was significant in water 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 result proved that drain spacing of 7.5 m and drain depth of 80 cm was 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 recommended for amelioration of water logging.

References

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

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

Shao. X.H., M.M.Hou, L.H.Chen, T.T.Chang and W.N.Wang 2012. Evaluation of Subsurface Drainage Design Based on Projection Pursuit. Energy Procedia 16:747-752

Manjunatha.M.V., R.J.Oosterbaan and S.K.Gupta.2004.Performance of subsurface drainas for reclaiming waterlogged saline lands under rolling topography in Tungabhadra irrigation project in India. Agricultural water Management 69:69-82

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