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ASSESSMENT OF WETTING PATTERN AND MOISTURE DISTRIBUTION UNDER POINT SOURCE DRIP IRRIGATION IN NYAGATARE - RWANDA

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ABSTRACT: A study was conducted to assess the performance of surface and subsurface drip irrigation systems using different irrigation water levels on water distribution in soil and wetting pattern and in order to establish relationship of moisture content, distance and depth relationship. The field experiment was conducted in sandy loam soil from October, 2014 to May, 2015 in the farm of University of Rwanda (UR) Nyagatare Campus. The experiment was laid out in strip plot design with three replications to study the effect of depth of placement of drip lateral and different levels of irrigation water.
The treatments are three levels of depth of laterals i.e. at surface, 10 cm depth from surface and 20 cm depth from surface. Soil moisture content at 0, 20 and 40 cm distances from emitter, and depths at 0 - 15, 15 - 30 cm depths was determined every 30 days before and 24 hours after irrigation to estimate soil profile moisture depletion. Based on wetting pattern radius, a linear equation was developed to evaluate relationship at the surface drip irrigation and subsurface drip irrigation at two considered depths (10 cm and 20 cm). For Vertical wetted depth, they were: Y (0 cm) = 0.217X + 5.2203, R^2 = 0.9532 (surface drip), Y (10 cm) = 0.2996X + 5.8946, R^2 = 0.9647 (subsurface drip, 10 cm depth) and Y (20 cm) = 0.2927X + 6.7402, R^2 = 0.957 (subsurface drip, 20 cm depth). In case of horizontal wetted radius, the obtained equations were: Y (0 cm) = 0.217X + 5.2203, R^2 = 0.9532 (surface drip), Y (10 cm) = 0.2996X + 5.8946, R^2 = 0.9647 (subsurface drip, 10 cm depth) and Y (20 cm) = 0.2927X + 6.7402, R^2 = 0.957 (subsurface drip, 20 cm depth). All these values of regression coefficients indicated that the variation of vertical wetting front and horizontal wetted radius was highly correlated to the time increase.

KEYWORDS: Moisture content, wetting pattern, irrigation, regression analysis, irrigation scheduling.

1 INTRODUCTION

Land and water are the two basic pre-requisites for life. The demand for these two natural resources is increasing more and more due to the escalation of population, large scale industrialization and food needed for the growing population.

Efficient utilization of available water resources is crucial for Rwanda with only 2.7% of potential cultivated land is under irrigation (Marshland, hillside and small scale irrigation). Agriculture sector consumes more than 10 % of the water resources of the country, and continues to be the major water-consuming sector due to the intensification of agriculture (MOWR, 1999, Iyer and Ramasamy, 2003). However, it accounts for 33% of the national gross domestic product and 70 % of exports (Rwanda development Board, 2014).

The Government of Rwanda, through the Ministry of Agriculture and Animal Resources (MINAGRI), is keen to transform the promise offered by modern irrigation technology from potential into reality in its pursuit of food security. Hence irrigation project sites are developed in different Districts of Rwanda like: Bugesera, Rwamagana, Nyagatare, Kirehe, Kayonza, Gasabo, Muhanga, Nyanza, Ruhango, Karongi and Gicumbi; to ensure sustainable production of food, cash, export and industrial crops.

Although Rwanda possesses considerable water resources, they are not evenly distributed uniformly. For example, while water is abundant in the marshlands, facilities for storing it elsewhere are lacking. This explains why farming during dry season agriculture is limited. Agriculture production in the Eastern and Southern parts of Rwanda, where rainfall is not uniformly distributed, is especially affected.

This case was observed also in season A of 2015 started from October/ 2014 up to February 2015 usually characterized with long rainfall season (Mid-February to end of May), Bart (1993), where rain occurred only for one month and half i.e from April to mid-May and affected the production especially for rain fed crop in Eastern and Southern part of Rwanda.

The ministry of Agriculture through its projects like government irrigation project and task force of irrigation and mechanization has increased surface irrigation land especially for rice crop. Recently MINAGRI has implemented pressure irrigation 900 ha at Matimba and 600 ha at Nasho; among of those 1500ha only 90ha were drip. Considering the above reason it seems that drip irrigation is not familiar here in Rwanda and they are no more literature and teaching material available on it. Moreover, determination of quantity and direction of water flow is very important for sustainable land management (Sariyev, 2007). While deeper lateral depth leads to the reduction of soil evaporation, a deep installation of emitters can increase water losses due to deep percolation and decrease availability of water for crop roots (Dukes, 2005). Lateral depths are mostly poorly studied as a treatment variable and little information is available on it

Due to the problems given in above section; artificial supply of water is required to meet crop water requirement and maintained sustainable agriculture, this technology is called irrigation. Hence the justification of this research with the following objective of Assessment of wetting pattern and moisture distribution under point source drip irrigation

2 Study Area

The field experiment was conducted to assess the performance of drip irrigation system at different placement depths of laterals with different irrigation water levels during January to May 2015. The study was conducted in the farm of University of Rwanda- Nyagatare Campus.

2.1 Weather and climate

The mean annual rainfall is 850 mm distributed during rainy days with an annual mean maximum and minimum temperatures of 32^0C and 15^0C respectively.

The average maximum and minimum relative humidity were 92 % (8:22 hrs) and 39 % (14:22 hrs). The mean daily evaporation ranges from 3.5 to 7.6 mm.

2.2 Soil properties

The soil of the experimental area belongs to sandy loam in texture. The physical and chemical properties are given in Table 3.1.

Table 2.1 Soil characteristics of the experimental field

Particulars	Composition
A. Textural composition	
Sand, %	64.43
Silt, %	22.15
Clay, %	13.42
Textural class	Sandy loam
B. Chemical properties	
pH	7.8
EC, dS m^{-1}	0.17
Available N, kg ha^{-1}	229
Available P, kg ha^{-1}	10.1
Available K, kg ha^{-1}	179
C. Physical properties	
Bulk density, gm / cm^3	1.52
Field capacity, %	23.8
Permanent wilting point, %	10.02
Saturated hydraulic conductivity, m s^{-1}	2.81×10^{-6}

Source: ISAR, 2005

2.3 IRRIGATION SOURCE

The irrigation water was deviated from public pipe line near the experimental field and was used for irrigation.

3 METHODOLOGY

3.1 FIELD PREPARATION

The experimental plot was thoroughly ploughed and the pits of 30 cm x 30 cm x 30 cm were prepared at a spacing of 1.5 m x 1.5 m. Then the layout was taken up and the drip irrigation system installed.

3.2 DESIGN AND TREATMENTS

3.2.1 EXPERIMENTAL DESIGN

The experiment was laid out in a plot design with three treatments each replicated three times.

- T1S1 - Drip lateral at surface with irrigation water at 1.0 IW / CPE ratio
- T2S1 - Drip lateral at 10 cm depth from surface with irrigation water at 1.0 IW / CPE ratio
- T3S1 - Drip lateral at 20 cm depth from surface with irrigation water at 1.0 IW / CPE ratio

3.2.2 IRRIGATION SCHEDULING

Irrigation water was given to the crop for all treatments based on IW/CPE ratio, where IW refers to irrigation water and CPE is the cumulative pan evaporation i.e. the sum of daily evaporation from standard open pan. Irrigation was given once in three days interval for all the treatments.

3.3 Wetting pattern measurement

3.3.1 Horizontal wetted zone

The average radius of the wetted zone was estimated over time during emission by measuring the actual distance in four directions as the wetting pattern has almost a circular shape using the measuring scale. The measurement was done for each irrigation system i.e. surface (lateral laid at 0 cm depth) and subsurface (laterals laid at 10 cm and 20 cm depth) for further investigation on the efficiency of each system according to treatments of the study.

3.3.2 Vertical wetted depth

Immediately after measuring the horizontal wetting front, the discharge was stopped. Then, the soil was cut vertically along downward to record the vertical movement of wetting front after the specified time. The vertical wetted depth was measured exactly below the emitter position.

The wetting pattern was measured at the end of 10, 20, 30, 45 and 60 minutes of the operation of drip irrigation system.

4 Results

The results obtained from the study were analyzed to provide basic information of soil moisture movement under surface and subsurface drip irrigation. The results obtained on the above investigation are presented and discussed in the following section.

4.1 Moisture distribution in soil during different period

The moisture content values at 0, 20 and 40 cm distances from emitter point and 0 – 15 cm and 15 – 30 cm depths for all the treatments i.e. those including (0 cm depth) surface laterals, 10 cm and 20 cm depth laterals each receiving irrigation. The contour maps of moisture distribution were drawn one before irrigation (figure 4.1), and the other at 30, 60, 90 and 120 DAS (DAS: Days after sowing).

The percentage of moisture was decreasing with increase in distance from the emitting point in both cases investigated i.e. before and 24 hours after irrigation. The surface soil appeared to be almost dry before irrigation in upper depth of soil say from surface to 15 cm depth. However 24 hours after irrigation is supplied, the moisture content for the treatments of surface laterals became higher from surface to 15 cm deep and lesser in the depth of 15 – 30 cm.

4.1.1 Moisture distribution in soil before irrigation for different treatments

The soil depth of 0 -15 cm in all the treatments was almost dry before irrigation, while moving downward the soil depth became moist. For all the treatments, before irrigation, the soil moisture content was almost in equal values moving downward the soil profile (Table 4.1).

4.1.2 Moisture distribution in surface drip irrigation treatments

In most of the cases of irrigation levels, moisture content appeared to be less at surface and increased proportionally with the depth as observed at different periods of plant growth. It was lower in the depth of 0 – 15 cm and relatively higher in the depth of 15 – 30 cm. This was most likely due to the high evaporation and infiltration from the surface.

While analysing the horizontal behaviour of soil moisture, the general trend showed that the moisture decreased with increase in distance from the emitting point for all the treatments (Table 4.1 and figures 4.1). This indicates that the plants were beneficiating more water near the emitting point than at other points of the wetted zone area. The percentage moisture decreased linearly in the order of: 0 cm > 20 cm > 40 cm. This could be justified by the quantity of water applied which could be more in first case and less in second one. Similar results were reported by Philip (1984) and Muthuchamy (1998) that the moisture content was decreased while the distance from the emitter point increased.

Table 4.1 Moisture content (%) before irrigation at 30, 60, 90 and 120 DAS

Treatment	Depth (cm)	Distance from emitter (cm)											
		At emitter				20				40			
		30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T1S1	0 – 15	12.9	11.09	11.32	12.56	10.99	9.97	10.08	11.52	13.11	11.86	10.68	10.17
	15 – 30	13.73	13.04	13.13	14.12	12.69	11.52	12.26	13.22	11.42	9.91	12.44	11.22
T1S2	0 – 15	13.46	11.51	12.35	13.33	12.43	12.31	9.55	10.20	10.65	10.79	11.31	11.36
	15 – 30	13.31	12.92	13.22	14.52	12.61	10.66	11.08	11.68	10.84	11.08	10.34	12.55
T1S3	0 – 15	11.21	10.16	10.99	11.07	10.13	9.75	10.11	9.67	8.86	8.66	6.25	10.22
	15 – 30	12.41	12.54	12.11	12.51	11.07	10.68	11.59	11.89	10.11	9.88	9.26	10.26
T2S1	0 – 15	11.28	12.12	12.86	12.29	10.16	11.46	11.1	11.08	9.18	10.12	10.29	10.86
	15 – 30	13.34	16.14	13.41	14.41	12.79	14.43	12.76	13.36	10.38	12.02	12.66	12.56
T2S2	0 – 15	10.65	11.84	10.59	11.77	9.95	10.64	10.11	10.24	10.64	8.97	9.15	9.83
	15 – 30	12.08	14.62	13.31	13.84	11.08	13.26	11.91	11.66	11.98	11.15	10.53	10.48
T2S3	0 – 15	10.14	11.21	11.34	11.51	10.05	10.42	10.73	10.81	9.78	10.12	9.97	10.18
	15 – 30	12.36	12.69	12.74	13.39	12.53	11.51	11.84	11.54	12.4	11.03	10.96	11.96
T3S1	0 – 15	11.42	12.79	11.17	11.26	10.01	11.63	10.09	11.09	9.75	10.51	10.2	9.93
	15 – 30	13.24	14.07	13.13	15.28	11.74	12.49	11.51	11.66	11.13	11.92	8.99	10.51
T3S2	0 – 15	10.91	12.26	11.51	11.79	11.09	10.76	10.67	12.44	7.65	8.23	10.16	9.98
	15 – 30	12.89	15.11	13.21	14.21	12.95	13.88	13.59	13.09	11	11.81	11.22	11.6
T3S3	0 – 15	10.80	12.03	11.29	12.31	7.65	10.52	10.36	10.52	6.83	8.51	9.93	11.47
	15 – 30	11.63	14.43	12.05	16.05	10.36	13.04	11.66	13.66	10.09	10.63	12.11	12.61

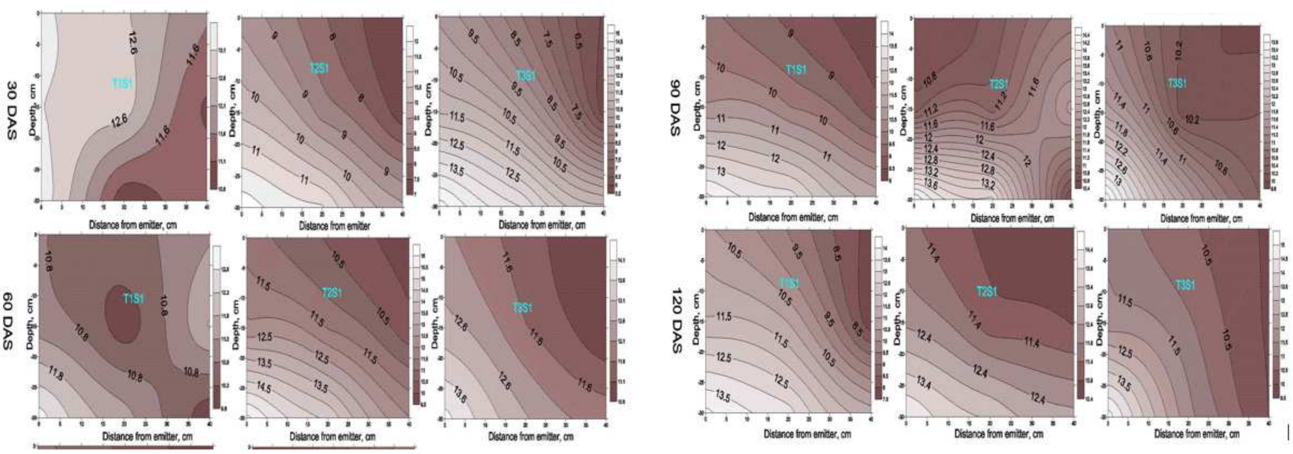

Figure 4.1 Moisture distribution before irrigation at surface, 10 cm and 20 cm depths

4.1.3 MOISTURE DISTRIBUTION IN SUBSURFACE DRIP IRRIGATION TREATMENTS

The soil moisture Content subsurface drip irrigation treatments are given in Table 4.2 for 10 and 20 cm placement depths of laterals respectively.

The contours plotted for different treatments of both 10 cm and 20 cm depths showed maximum depletion at a depth range of 0 – 15 cm while, it was reducing by depth of 15 – 30 cm (figure 4.2). This could be due to more evaporation on surface and the movement of water by gravity beneath the sandy loam soil was more to capillary hence water moved from upper layers to deeper ones. In addition, the water is directly supplied to the plant roots in the deeper depth especially for the treatments including 20 cm depth laterals. The percentage moisture decreased with increase in distance away from emitter as it was also observed in the treatments including surface laterals. Generally, the treatments including 20 cm depth laterals was superior to others to increase soil moisture in the depth range of 15 – 30 cm regardless the water levels applied and the stage of plant growth (Table 4.1).

From the above observation, subsurface drip irrigation was found to be superior to surface drip irrigation due to the following reasons:

- Since the water supply is below the ground surface, evaporation loss is minimum and,
- Application of irrigation water is direct at the rhizosphere zone and hence growth of plant is good.

4.1.4 MOISTURE DISTRIBUTION IN SOIL 24 HOURS AFTER IRRIGATION

4.1.4.1 SURFACE DRIP IRRIGATION TREATMENTS AFTER 24HOURS

The moisture content results showed the variation between treatments due to the water levels received. Considering the plant growth stage of 120 DAS at which the maximum values were found, the treatment gave 20.25 %.

The moisture content was higher at a ranging depth 0 – 15 cm than at 15 – 30 cm (Table 4.2). This could be due to the direct water application at surface and to the fact that the water infiltration after 24 hours was in progress and much moisture was still in the depth of 0 – 15 cm. Apart from this vertical water front advance, horizontal wetting advance was taking place and the maximum moisture content was near the emitting point and reduced as the distance away from emitter (Table 4.2). The figure 4.4, 4.5 and 4.6 illustrate the even distribution of soil moisture with the increase in moisture content vertically and the lateral decrease with increasing distance from emitting point.

The same results were reported by Chakraborty *et al.* (1998) that, relative higher soil moisture content by volume near the emitter and a decrease as the distance from emitting point increases.

Table 4.2 Moisture content (%) 24 hours after irrigation at 30, 60, 90 and 120 DAS

Treatment	Depth (cm)	Distance from emitter (cm)											
		At emitter				20				40			
		30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T1S1	0 - 15	18.01	18.51	18.38	**20.25**	15.86	15.13	14.86	16.46	13.88	12.98	12.54	14.32
	15 - 30	14.17	13.24	13.87	15.95	12.27	12.58	12.62	16.97	11.82	11.14	13.42	12.38
T1S2	0 - 15	16.87	15.17	16.21	17.73	13.81	12.98	14.04	14.35	12.24	13.55	13.79	12.76
	15 - 30	13.34	13.5	13.11	14.9	12.68	11.19	11.26	12.7	11.86	11.09	11.87	13.61
T1S3	0 - 15	15.25	14.06	14.23	16.58	13.62	12.72	12.72	14.32	11.13	12.8	11.63	12.4
	15 - 30	12.17	12.48	12.48	13.87	10.84	11.04	11.04	12.55	10.25	10.17	10.17	11.24
T2S1	0 - 15	14.24	14.52	14.38	16.86	12.66	13.06	12.21	13.9	11.62	11.98	11.14	11.89
	15 - 30	17.23	17.16	16.36	20.11	14.86	14.62	13.83	16.79	12.65	12.28	12.67	13.65
T2S2	0 - 15	14.51	13.23	13.27	15.52	12.35	12.46	12.64	13.64	11.24	10.87	11.17	11.59
	15 - 30	17.06	16.56	16.05	18.2	15.94	13.58	13.2	16.31	12.51	12.26	12.09	13.23
T2S3	0 - 15	14.23	13.87	12.99	13.89	12.18	11.56	11.23	12.23	11.95	9.91	10.03	10.93
	15 - 30	15.79	14.96	14.18	16.59	13.67	12.08	12.31	14.18	12.08	11.25	11.27	13.20
T3S1	0 - 15	13.23	13.08	12.22	16.22	11.27	11.17	11.62	13.62	12.42	12.54	12.56	12.03
	15 - 30	18.11	17.65	17.56	20.51	16.19	15.05	14.74	17.5	13.27	13.01	13.24	14.54
T3S2	0 - 15	13.53	12.78	12.43	14.43	12.36	11.12	11.46	13.43	11.55	12.04	10.48	11.48
	15 - 30	17.16	17.03	17.11	19.77	14.17	13.89	14.32	16.32	12.24	13.17	12.47	14.21
T3S3	0 - 15	12.28	12.14	12.41	14.49	11.68	11.03	11.49	12.79	10.14	10.31	10.04	11.81
	15 - 30	16.21	15.49	15.18	17.18	14.54	13.36	13.27	15.27	12.27	11.65	11.46	13.46

4.1.4.2 MOISTURE DISTRIBUTION IN SUBSURFACE DRIP IRRIGATION TREATMENTS AFTER 24HOURS

The moisture content observed 24 hours after irrigation was found to be higher in deeper installation (Table 4.2). Analyzing the contours of 10 cm and 20 cm depths of lateral placement at different irrigation place, the moisture content was evenly distributed 24 hrs after irrigation.

From Table 4.2 and figure 4.2 for all the plant growth stages (30, 60, 90 and 120 DAS) the soil moisture content was varying in both depths of 0 – 15 cm and of 15 – 30 cm and in the order: 20 cm > 10 cm > 0 cm (surface). This gradual decrease with the increase in distance was almost the general trend.

Contrary to surface drip irrigation, soil surface appeared moist but did not get saturated for subsurface irrigation when depth of placement of drip lateral was 10 and 20 cm at all growth stage. The soil moisture content was more at the depth of 15 – 30 cm than in 0 – 15 cm at all plant growth stages. Similar results were obtained by Singh and Rajput (2009) that the subsurface drip irrigation on onion where the soil moisture was more in 30 cm depth than the upper depth when the lateral was laid at 20 cm depth. The findings of Kheira (2009) are in conformity with the results of the present where the soil moisture at 30 and 45 cm depths was higher than in the upper layer when the lateral was laid at 25 cm depth. Arbat *et al.* (2010) reported the similar trend of moisture behavior where it was lesser in nearly surface ground and more in deeper layers beyond 15 cm depth. The water distribution in the soil profile for irrigated land by the subsurface drip system (10 cm and 20m placement depths of laterals, and almost at all growth stages. Therefore, it could be concluded that under subsurface drip, the water available in root zone was more sufficient for plant growth. This might have resulted from minimum evaporation loss with this system.

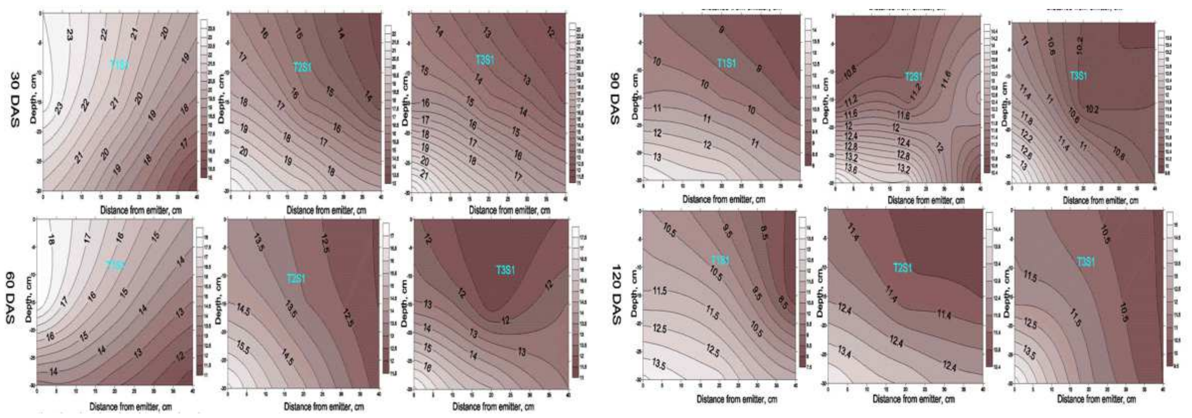

Figure 4.2: Moisture distribution 24 hours after irrigation at surface, 10 cm and 20 cm depths from surface treatments at 30, 60, 90 and 120 DASF

4.2 WETTING PATTERN VS TIMES RELATIONSHIP

The horizontal and vertical water front advance were measured and shown in Table 4.3. The wetted horizontal radius and wetted depth for various time of emission were observed at surface, 10 cm and 20 cm depth. Different regression equations were fitted for the horizontal wetted radius and vertical wetted depths (figure 4.3). A view of wetting pattern of surface and subsurface drip.

4.2.1 HORIZONTAL WETTED RADIUS

The values of horizontal wetted zone radius increased progressively from 10. 2 to 15.8 cm for surface lateral, 6.4 to 12.3 cm for lateral laid at 10 cm depth and 5.6 to 10.9 cm for lateral laid at 20 cm beneath the soil from 10 minutes to 60 minutes emitter operation. Table 4.3 shows that the horizontal wetted zone radius increased linearly with increase in elapsed time. It was observed the faster movement of wetting front in horizontal direction for surface drip treatments than the treatments of subsurface lateral installations at 10 cm and 20 cm depth.

From observed data, an equation of the linear model Y = AX + C was fitted for different depths at which the laterals were laid. This helped to evaluate the surface drip irrigation and subsurface drip irrigation at two considered depths (10 cm and 20 cm).
The following equations representing predicted values were obtained:

(i) Y (0 cm) = 0.1026X + 10.437 (surface drip)

R^2 = 0.8062

(ii) Y (10 cm) = 0.1059X + 6.4858 (subsurface drip, 10 cm depth)

R^2 = 0.8621

(iii) Y (20 cm) = 0.1035X + 5.543 (subsurface drip, 20 cm depth)

R^2 = 0.891

Where,

Y = horizontal wetted radius, cm

X = elapsed time and A, C = constants

The range of variation of obtained regression coefficients varied between 0.8 and 0.9 (maximum value being 1 and the minimum 0). This states that the obtained regression line perfectly fits the data. From these equations, the variation of the constants is due to different depths of lateral placement. The coefficients of deterministic (R^2 = 0.8062, R^2 = 0.8621and R^2 = 0.891for surface lateral, lateral placed at 10 cm depth and lateral placed at 20 cm depth respectively) indicated that the variation of horizontal wetted radius was highly correlated to time increase.

4.2.2 VERTICAL WETTED DEPTH

The depth of wetting ranged from 6.5 to 17.2 cm, 7.6 to 23 cm and 8.2 to 23.4 cm for 60 minutes of emission for the surface lateral, 10 cm depth lateral and 20 cm depth lateral respectively. Similar to horizontal wetting front advance, the vertical wetting front advance increased with increase in elapsed time (Table 4.3, 4.7).Inversely to horizontal wetted zone radius, the wetting front advance in vertical direction was faster in the subsurface treatments i.e. those including lateral placed at 10 cm depth and 20 cm depth respectively with the supremacy of the treatments of 20 cm lateral depth. This vertical wetting front was lesser in surface drip treatments (figure 4.8). The similar functional relationship was observed by Selvaraj (1997), Muthuchamy (1998) and Fazilah (2009).

Equation of the linear model Y = AX + C was fitted using observed data for different depths at which the laterals were laid and the obtained equations can be used for prediction. The following equations were obtained (figure 4.3):

(i) Y (0 cm) = 0.217X + 5.2203 (surface drip)

R^2 = 0.9532

(ii) Y (10 cm) = 0.2996X + 5.8946 (subsurface drip, 10 cm depth)

R^2 = 0.9647

(iii) Y (20 cm) = 0.2927X + 6.7402 (subsurface drip, 20 cm depth)

R^2 = 0.957

Where,

Y = horizontal wetted radius, cm

X = elapsed time and A, C = constants. The range of variation of obtained regression coefficients varied around 1 (maximum value). This states that the obtained regression line perfectly fits the data.

Similar to the variation of horizontal wetted radius, the regression coefficients (R^2 = 0.9532, R^2 = 0.9647, R^2 = 0.957 for surface lateral, lateral placed at 10 cm depth and lateral placed at 20 cm depth respectively) indicated that the variation of vertical wetting front was highly correlated to the time increase. From these equations, the variation of the constants was due to variation in depths of lateral placement. The similar functional relationship was also observed by Selvaraj (1997). For subsurface drip irrigation system Singh *et al*. (2006) reported that, at different duration of water application, the maximum wetted depth and minimum wetted width were found in subsurface drip laid at different depths of 0, 5, 10 and 15 cm than the surface drip.

Table 4.3 Horizontal wetting front advancement and vertical wetted zone depth

Time (min)	Horizontal Wetted zone radius (cm)			Vertical wetted zone depth (cm)		
	Surface (0 cm)	10 cm depth	20 cm depth	Surface (0 cm)	10 cm depth	20 cm depth
10	10.2	6.4	5.6	6.5	7.6	8.2
20	13.3	9.5	8.5	9.6	12.2	13.1
30	14.0	10.3	9.1	12.7	16.5	17.2
45	15.0	11.4	10.2	15.9	19.6	20.1
60	15.8	12.3	10.9	17.2	23	23.4

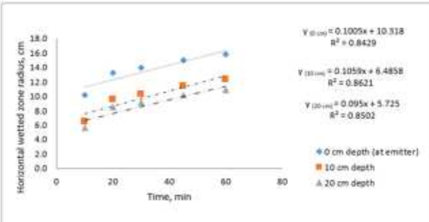

Figure 4.3. Horizontal wetted radius vs time

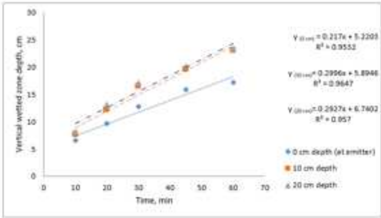

Figure 4.4. Vertical wetted depth vs time

Plate 4.5. Measurement of wetting pattern at 30cm depth

Plate 4.6 Measurement of wetting pattern at surface

5 SUMMARY AND CONCLUSION

The field experiment was laid in strip plot design with nine treatments replicated thrice. Two irrigation systems i.e. surface and subsurface drip irrigations were evaluated with respect to depth of lateral placement and three levels were considered: surface, 10 cm and 20 cm depth of lateral placement. This factor of depth of lateral placement was combined with irrigation water level factor to form the treatments of the study.

The percentage of moisture was decreasing with increase in distance from the emitting point in both cases investigated i.e. before and 24 hours after irrigation. The surface soil appeared to be almost dry before irrigation in upper depth of soil say from surface to 15 cm depth. However 24 hours after irrigation is supplied, the moisture content for the treatments of surface laterals became higher from surface to 15 cm deep and lesser in the depth of 15 – 30 cm. In case of subsurface drip treatments, the moisture content observed 24 hours after irrigation was found to be higher in deeper installation. Analyzing the contours of 10 cm and 20 cm depths of lateral placement at different irrigation levels, the moisture content was evenly distributed 24 hrs after irrigation.

To evaluate the surface drip irrigation and subsurface drip irrigation system a linear regression equation was based on two considered depths (10 cm and 20 cm). For Vertical wetted depth, they were: Y (0 cm) = 0.217X + 5.2203, R^2 = 0.9532 (surface drip), Y (10 cm) = 0.2996X + 5.8946, R^2 = 0.9647 (subsurface drip, 10 cm depth) and Y (20 cm) = 0.2927X + 6.7402, R^2 = 0.957 (subsurface drip, 20 cm depth). In case of horizontal wetted radius, the obtained equations were: Y (0 cm) = 0.217X + 5.2203, R^2 = 0.9532 (surface drip), Y (10 cm) = 0.2996X + 5.8946, R^2 = 0.9647 (subsurface drip, 10 cm depth) and Y (20 cm) =

0.2927X + 6.7402, R^2 = 0.957 (subsurface drip, 20 cm depth). All these values of determination coefficients indicated that the variation of vertical wetting front and horizontal wetted radius was highly correlated to the time increase.

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