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Study of soil moisture distribution under different mulching methods

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ABSTRACT

Mulching techniques are used for the conservation of moisture beneath the root zone and to reduce the evaporation rate. Soil moisture distribution under the mulching techniques is also important for good crop growth and root development. Soil water movement is dependent on the physical properties of water as well as equally depends on the conservation techniques. The present study was carried out in the School of Agriculture, Lovely professional university to study the soil moisture distribution under different mulching treatments. The four mulching methods and one no mulch technique were used as a conservation technique and moisture content were measured at 5, 10, 15, and 20 cm depth vertically and the same distance laterally. From the experiment, the results showed that the black and silver plastic mulch conserved maximum average moisture content (22.33 and 22.67 %) up to 20 cm depth. The lateral and vertical water movement in plastic mulch was superior to the no mulch technique. Minimum soil moisture content (15.26 %) was recorded in the soil mulch technique at 5 cm depth and it decreases as the lateral distance increases from the emitter. Paddy straw mulching technique conserved better moisture at depth 0-10 cm compared to no mulch and soil mulch technique.

Key words: *Conservation technique, Moisture content, Plastic mulch, Uniformity coefficient*

Introduction

Drip irrigation also known as trickle irrigation is an efficient advanced method of irrigation due to its higher water use efficiency and nutrient productivity. The water application efficiency of drip irrigation is up to 90% and water saving more than 50 % compared to surface irrigation. Drip irrigation trickles the water as per requirement and maintain the optimum soil moisture near to the crop root zone, and also enhance the nutrient uptake efficiency resulted better quality produce (Kumar *et al.,* 2015). Soil water movement or moisture content varies as per the texture of the soil. More the pores implies the rapid vertical movement of water whereas lower infiltration rate may increases lateral water movement initially. The wetting front in sandy loam soil was extended up to 60 cm at daily irrigation schedule and up to 100 cm under a weekly schedule (Earl and Jury, 1977). Generally water loss due to evaporation occurred at the soil surface and relates to the water movement in to the soil in all three direction. Mostafa (2014) reported that evaporation rate was high in saturated zone near to the emitter especially in clay soils and lateral movement of water is more than vertical due to its low infiltration rate of soil. Selvapurmal *et al.* (2020) stated that the moisture content increase in the lower horizons due to water stored in soil pores and minimum evaporation rate in lower horizons. Low moisture content occurred on the surface layer than in depths this may be because of higher evaporation compared to lower lay-

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ers. Moisture content was gradually decreased with the increased in horizontal distance from the emitter. Spacing between emitters mostly affected on the uniformity of soil moisture distribution under surface drip irrigation system of soil moisture whereas influence of lateral spacing was not considerable (Badr and Abuarab, 2013; Neetha Shaju, 2017). Inaccurate depth of placement of lateral beneath the soil failed to supply the enough moisture to crop may be lead in the stressful water condition resulted in decreased in yield Dukes and Scholberg, (2005). Al-Ghobari and El Marazky (2012) evaluated the wetting patterns at different depth and distances from the emitter at 24 and 48 hr after irrigation with three irrigation scheduling techniques for tomato under drip and surface irrigation system, resulted that soil moisture distribution patterns showed the vertical movement of soil moisture was higher than the horizontal movement under both DI and SI systems. Kaute and Gaikwad (2011) studied the soil moisture distribution pattern in sandy loam soil at two discharge rate and showed that the lateral water movement was less (27.76 cm) as compared to vertical water movement (37.22 cm) in the starting time and its increment continued with respect to time. The bulb of moisture content took shape alike of onion, this indicated the proper soil moisture distribution. Vadar *et al.* (2019) recorded that the lateral placed between 15 to 20 cm shows good distribution of soil moisture.

The moisture distribution also depends on the hydraulic of drip irrigation thus it is needed to study the coefficient of uniformity of drip system. Al-Ghobari and El Marazky (2012) reported the average coefficients of uniformity for the drip and surface irrigation systems were 84.32 and 88.72 per cent respectively. Changade *et al.* (2009) recorded the emission uniformity of gravity fed drip irrigation system was 90.58% and the manufactures coefficient of emitter was 0.0428 and the system declared as good as per ASAE interpretation. The movement of water in soil was also dependent on the discharge rate and operating pressure. Kumar *et al.* (2015) stated that wetting fronts in horizontal direction was more with higher operating pressure and discharge rate.

Organic and inorganic mulching showed the significant effect on the soil moisture distribution beneath the root zone lateral and vertical down direction. Organic and inorganic mulching done in potted plants could conserve the soil moisture more than 35 % compared to no mulch condition and did not required irrigation up to six week approximately (Stelli *et al.*, 2018). Mulching material retard the evaporation rate, increase the microbial activity, maintain the optimum soil moisture and soil temperature for productive crop growth (Tarara 2000). Sharma *et al.* (2015) recorded that black plastic mulch significantly saved maximum soil moisture (49 % and 44 %) compared to paddy straw mulch measured at 15 cm and 30 cm depth respectively. The mulching techniques also reduced the soil moisture variability during entire the crop cycle and permit good distribution of soil moisture in case of clay soil compared to sandy loam soil (Monteiro *et al.*, 2013). Considering the above relationship between the soil moisture distribution, soil type and conservation techniques, the present experiment was conducted to study the soil moisture distribution under different mulching techniques irrigated by drip irrigation.

Materials and Method

Study area: The present study was conducted in summer season of year 2019 at School of Agriculture, Lovely Professional University, Phagwara Dist. Kapurthala. The experimental area is situated in Phagwara block in Kapurthala district at Latitude: $31^0$21'00"North; Longitude: $75^0$77'99"East. Tropical brown soil occurs in Phagwara block and northern part of Kapurthala district.

Soil physical and chemical properties: The Physical and chemical properties of experimental plots were determined using the standard procedure. The soil texture of the experimental plot was sandy loam soil, infiltration rate was 2.7 cm/h, field capacity recorded as 20.05 per cent and permanent wilting point was 9.3 per cent. The pH was 7.31 and electrical conductivity was 0.49 mmhos/cm termed as good soil.

Drip irrigation system: Drip irrigation system consist of main (75 mm dia.) buried at 45 cm depth to avoid the hindrances during the tillage operation, submain (63 mm), control valve, pressure gauge, flush valve, inline dripper lateral (4 lph) and lateral control valve. Uniform water application is the major concern to estimate the irrigation efficiency and was determined by hydraulic of emitter viz. uniformity coefficient, emission uniformity and distribution uniformity and presented in Table 1.

Study methods: The mulching treatment was the black plastic mulch (T_1), silver plastic mulch (T_2), paddy straw mulch (T_3), soil mulch (T_4) was considered as moisture conservation techniques and the non-mulch treatment (T_5) is considered as a control. The thickness of plastic mulch material was 25 micron and soil mulch (T_4) was the conservation techniques in which drip lateral was placed at 20 cm depth beneath the soil surface. The bed under different mulching treatment was irrigated with drip irrigation run for 1 hour at 1 kg/cm^2 with the average discharge 3.3 lph. Soil samples were taken after 24 hr duration at 5, 10, 15 and 20 cm depth vertically and at same distance laterally with the help of soil sampler from the each bed and soil moisture content was measured by gravimetric method. The moisture content (db) at different mulching treatment was tabulated and presented in graphically as below.

Results and Discussion

Performance of drip irrigation system: Performance of drip irrigation was evaluated based on the uniformity coefficient, distribution uniformity and emission uniformity by measuring the discharge from first, middle and end laterals (table 1). The maximum discharge observed as 3.52, 3.48 and 3.46 lph at starting point of the lateral in middle, first and last lateral respectively with overall average discharge of system was 3.33 lph which was 83.33 % of manufacturer discharge (4 lph).

The maximum value of uniformity coefficient (97.05 %) and distribution uniformity (96.12 %) recorded in middle lateral with overall average uniformity coefficient was 96.34 % and distribution uniformity (95.09 %) respectively. The coefficient (%) values more than 90 per cent is considered as excellent design of drip system. The water could not reach with proper pressure at the tail end of lateral so it can be concluded that, as length of lateral increases, distribution uniformity decreases (Kumar 2014). The average emission uniformity of the present system was recorded as 95.10 % which was more than 90 per cent compared to the actual manufactured discharge is considered as excellent. Shashikant (2016) experienced that the emission uniformity as increases as the pressure increases and recorded maximum emission uniformity (95.75 %) at pressure 1.5 kg/cm^2. The similar results have been reported by Changade *et al.* (2009) and Deshmukh *et al.* (2014).

Soil moisture distribution pattern

Soil moisture status at black plastic mulch

Data from the table 2 indicated that the average maximum moisture content was 22.33 per cent at 20 cm depth just below the emitters. Minimum moisture content (18.11 %) was observed at distance 20 cm horizontally at 5 cm depth and the average minimum moisture was 19.78 per cent at same depth (5

Table 1. Evaluation of hydraulic performance of drip irrigation system

Variation	First lateral	Middle lateral	Last lateral	Average
Maximum Discharge (lph)	3.48	3.52	3.46	3.49
Minimum Discharge (lph)	2.98	3.17	3.00	3.05
Average of Discharge (lph)	3.33	3.35	3.31	3.33
Average of 1/4 the lowest emitter discharge (lph)	3.14	3.22	3.14	3.17
Uniformity coefficient (%)	95.78	97.05	96.18	96.34
Distribution Uniformity (%)	94.29	96.12	94.86	95.09
Emission Uniformity (%)	94.29	96.70	94.29	95.10

Table 2. Soil moisture content (%) at vertical and horizontal distance under black plastic mulch.

Vertical distance (cm)	Horizontal distance (cm)				
	5	10	15	20	Average
5	21.23	20.05	19.74	18.11	19.78
10	22.14	20.90	20.00	19.13	20.54
15	22.95	21.43	20.30	19.00	20.92
20	23.00	22.84	20.41	18.73	21.25
Average	22.33	21.31	20.11	18.74	

cm) whereas maximum average soil moisture was obtained as 21.25 per cent at 20 cm depth horizontally. Maximum and minimum average soil moisture was obtain as 22.33 and 18.74 per cent at depth 20 cm. Minimum average moisture content (18.73 %) at 20 cm vertically and horizontally indicates the less moisture content availability at 20 cm away from the point source. Good moisture content available near to the crop root zones i.e. up to 20 cm below the emitter and 15 cm away from the emitters.

As shown in Figure 1, the maximum soil moisture content at 20 cm depth near to the point source was 23.00 % showed good vertical movement of water but at the same time less moisture content obtained near to the point source at 5 cm depth. This may be due to the slight evaporation at surface soil from the hole made for plantation. As the black sheet absorbed more solar radiation that may have resulted in increase in the soil temperature and increase to evaporation. The soil moisture content decreased horizontally away from the point source indicating that there was slow water movement laterally. It was clear that the moisture content up to field capacity was available up to 15 cm horizontal distance and 20 cm vertically from the point source. Similar results reported by Sharma and Meshram (2015) during the study of soil moisture content under black plastic mulch and paddy straw mulch irrigated by drip irrigation for capsicum.

Soil moisture study at silver plastic mulch

Table 3 presented the soil moisture content under silver plastic mulch (T_2) and data indicated that, minimum moisture content (18.19 %) was observed at distance 20 cm horizontally at 5 cm depth and the average minimum moisture was 20.24 at same depth (5 cm) whereas, maximum average soil moisture was obtained as 21.38 % at 20 cm depth horizontally. Maximum and minimum average soil moisture was obtain as 22.67 % and 18.75 % at depth 20 cm. Minimum average moisture content (18.62 %) at 20 cm vertically and horizontally indicates the less moisture content availability at 20 cm away from the point source.

Soil moisture distribution under silver plastic mulch was graphically represented in Fig 2. Results indicated that the maximum soil moisture content (23.36 %) at 20 cm depth near to the point source showed the good vertical movement water. Good moisture content available near to the crop root zone, i.e. up to 20 cm below the emitter and 15 cm away from the emitters. There was not much variation in 0 to 10 cm depth and 10 to 20 cm depth vertically but about 4 % moisture content difference

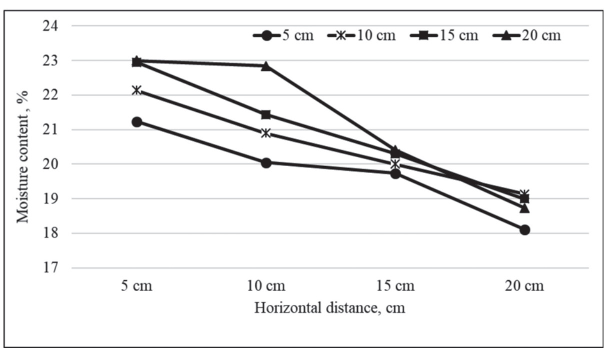

Fig. 1. Soil moisture distribution under black plastic mulch

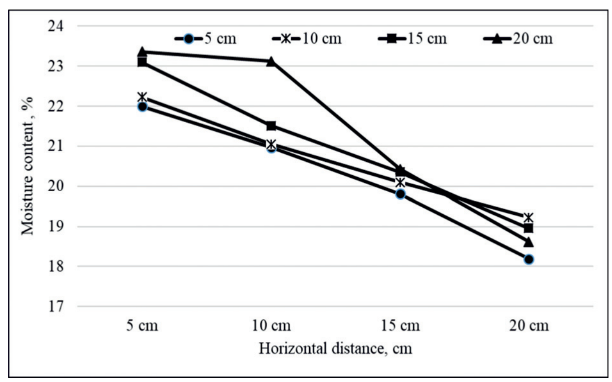

Fig. 2. Soil moisture distribution under silver plastic mulch

Table 3. Soil moisture content (%) at vertical and horizontal distance under silver plastic mulch.

Vertical distance (cm)	Horizontal distance (cm)				
	5	10	15	20	Average
5	22.00	20.97	19.81	18.19	20.24
10	22.23	21.05	20.10	19.23	20.65
15	23.10	21.51	20.35	18.96	20.98
20	23.36	23.12	20.43	18.62	21.38
Average	22.67	21.66	20.17	18.75	

between point source to 20 cm distance horizontally. It was observed that, the soil moisture content in silver plastic mulch is more than the black plastic mulch sheet and this may be due to less evaporation due to minimum soil temperature under silver plastic mulch. The Soil moisture content was decreased horizontally away from the point source indicating slow water movement laterally. Same as per the black plastic mulch, it was clear that the moisture content up to field capacity was available up to 15 cm horizontal distance and 20 cm vertically from the point source. Sharma and Meshram (2015) recoded the maximum moisture content at 15 cm depth which corroborated the results obtain in present study.

Soil moisture study in paddy straw mulch

Soil moisture content under paddy straw mulch recorded in Table 4 in which data indicated that, average maximum moisture content of 21.89 per cent at 20 cm depth just below the emitters and minimum moisture content (18.00 %) was observed at distance 20 cm horizontally at 5 cm depth. Maximum and minimum average soil moisture was obtain as 21.89 and 18.74 per cent at depth 20 cm. Minimum average moisture content (19.00 %) at 20 cm vertically and horizontally indicates the moisture content availability was below than field capacity at 20 cm away from the point source. Moisture content up to field capacity was available near to the crop root zone i.e. up to 20 cm below the emitter and 15 cm away from the emitters.

Soil moisture distribution pattern under paddy straw mulch was diagrammatically shown in figure 3. Obtained results indicates that the maximum soil moisture content at 20 cm depth near to the point source was 22.60 per cent showing the good vertical movement of water. There was not much variation in 0 to 10 cm depth and 10 to 20 cm depth vertically below the point source but moisture content less than field capacity was observed at 10 to 20 cm horizontal distance from point source. The less moisture content was observed near to surface may be due to moisture absorbed by paddy straw or evaporation. The soil moisture content decreased horizontally away from the point source indicating slow water movement laterally. The above results find supports from Shirahatti *et al.* (2010), who recorded the moisture content increased vertically (0-10) cm just below the emitter source and decreased as the distance

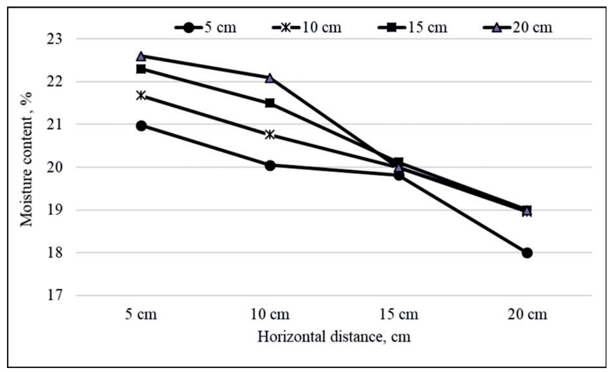

Fig. 3. Soil moisture distribution under paddy straw mulch

Table 4. Soil moisture content (%) at vertical and horizontal distance under paddy straw mulch.

Vertical distance (cm)	Horizontal distance (cm)				
	5	10	15	20	Average
5	20.98	20.05	19.82	18.00	19.71
10	21.68	20.76	20.00	18.95	20.35
15	22.30	21.50	20.12	19.00	20.73
20	22.60	22.09	20.00	19.00	20.92
Average	21.89	21.10	19.99	18.74	

Table 5. Soil moisture content (%) at vertical and horizontal distance under soil mulch (20 cm depth)

Vertical distance (cm)	Horizontal distance (cm)				
	5	10	15	20	Average
5	15.26	14.92	14.72	14.65	14.89
10	21.08	20.90	20.10	17.80	19.97
15	23.56	23.50	22.60	19.83	22.37
20	24.80	24.60	23.00	20.50	23.23
Average	21.18	20.98	20.10	18.19	

from the trickle sources increases horizontally.

Soil moisture study at soil mulch

Soil moisture content at 5, 10, 15 and 20 cm depth under soil mulch treatment in which lateral placed at 20 cm below the surface was recorded and presented in Table 5. Result showed that the average maximum moisture content was recorded as 21.18 per cent at 20 cm depth just below the emitters. Data indicated that very less moisture content was observed at upper surface, i.e. at 5 cm depth horizontally but higher at depth 20 cm. Minimum moisture content (14.65 %) recorded at distance 20 cm horizontally at 5 cm depth which is less than field capacity. Maximum and minimum average soil moisture was obtain as 21.18 % and 18.19 % at depth 20 cm. Moisture content (20.50 %) at 20 cm vertically and horizontally indicates that the moisture content availability was near to field capacity. Moisture content more than field capacity was available near to the crop root zone, i.e. up to 20 cm below the emitter and 15 cm away from the emitters.

From Figure 4, results showed that the maximum soil moisture content observed at 15 - 20 cm depth near to the point source and ranged from 24.80 to 20.50 per cent shows the good availability of moisture. Less moisture content (14.89 %) was available near to the ground surface at 5 cm depth indicated

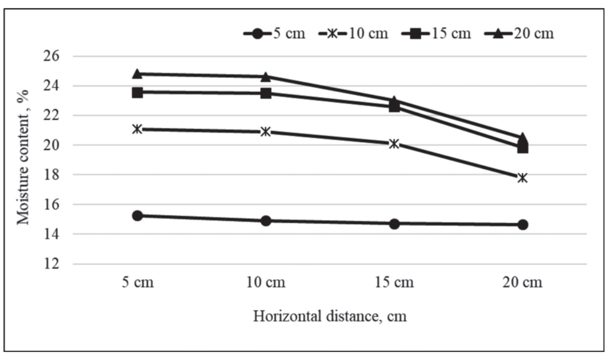

Fig. 4. Soil moisture distribution under soil mulch (Lateral placed at 20 cm depth)

that slow movement of water towards upward side from the point source. Patel and Rajput (2007), also recorded the dry conditions on surface of a sandy loam soil when drip tape placed at 0.1 m depth and this was due to the limited capillary water movement in sub surface irrigation technique. Moreover the water reaches to the surface of soil by upward movement may be loss due to evaporation. Enough moisture content at depth 20 cm below the surface of soil and near to the point source indicated the good root zone for the crop. The soil moisture content decreased horizontally and vertically upward away from the point source indicate that there was slow water movement in both directions. Distribution of moisture into the soil depends on hydraulics of drip irrigation and depth of lateral beneath the soil (Badr *et al.*, 2010; Vadar *et al.*, 2019). Douh *et al.* (2013) reported that, the lateral placed at 20 cm depth shows the circular shape curve of moisture content around the dripper with initial moisture content (29 %) near to the emitter which reduces up to 24.5 per cent after 4 hours and 18 per cent moisture content at 30 cm radial distance.

Soil moisture study in no mulch plot

Soil moisture distribution under no mulch condition was presented in table 6. Recorded data indicate that the average maximum moisture content was 20.79 per cent at 20 cm depth just below the emitters. Minimum moisture content (15.35 %) was observed at distance 20 cm horizontally at 5 cm depth and the average minimum moisture was 17.54 at same (5 cm) depth which was less than the field capacity. Maximum and minimum average soil moisture was obtain as 20.79 and 16.72 per cent at depth 20 cm. Away from the point source at 20 cm horizontal distance, average moisture content (16.72 %) indicates the moisture content availability was below than field capacity at 20 cm depth from the point source.

Soil moisture pattern under no mulch condition was demonstrated in Fig. 5. Which showed that the

Table 6. Soil moisture content (%) at vertical and horizontal distance under no mulch

Vertical distance (cm)	Horizontal distance (cm)				
	5	10	15	20	Average
5	18.70	18.52	17.60	15.35	17.54
10	20.60	19.56	18.80	16.80	18.94
15	21.75	20.90	19.00	17.60	19.81
20	22.10	21.92	19.30	17.12	19.86
Average	20.79	19.98	18.66	16.72	

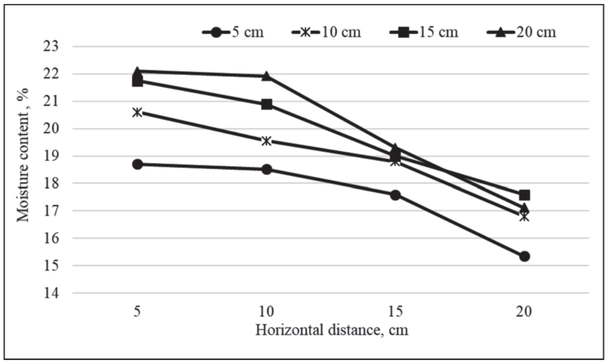

Fig. 5. Soil moisture distribution under no mulch

moisture content up to field capacity was available near to the crop root zone i.e up to 20 cm below the emitter and 10 cm horizontally from the emitters. Minimum moisture content was recorded at 5 cm depth as well as away from the emitter. Moisture content less than field capacity was observed near to surface may be due to more evaporation from surface soil. The Soil moisture content was decreased horizontally away from the point source indicating that there was very slow water movement laterally due to more evaporation rate. Kaute and Gaikwad (2011) also found similar results and observed that at the emitter discharge 2 lph, the horizontal water movement was more than vertical at initial level but vertical movement of water increased and horizontal water movement decreased with the increment of time. Al-Ghobari and El Marazky (2012) recorded the lowest soil water content in the surface layer and the maximum soil water content was in the 20 to 40 cm soil layer when irrigated with drip irrigation system.

Conclusion

Study of soil moisture distribution under different mulching treatment concluded that good moisture distribution was obtained below the emitted source at 15-20 cm depth in all mulch including no mulch treatment. Low moisture content was recorded near to the soil surface and away from the emitter source. Good vertical movement was observed but lateral movement was decreased with the increment of distance from the emitter.

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