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# SOIL MANAGEMENT PRACTICES TO IMPROVE IRRIGATION PERFORMANCE AND EGG PLANT WATER USE EFFICIENCY IN A CRACKED SOIL

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## Abstract

Vertisols cover extensive areas in the intermountain valleys of Iraq. These soils crack upon soil moisture loss and the formed cracks facilitate rapid transport of surface water into the subsoil via preferential flow. A large volume of water can be saved by practicing proper soil management practices. Sequential experimental were conducted encompassing laboratory, preliminary and field experiments. The field experiments were conducted over a cracked soil at a research farm located in the outskirt of Sulaimani city during the summer seasons of 2017 and 2018. The objectives were to improve the performance of a furrow irrigation and water use efficiency of eggplant under different treatments. The treatments encompassed: control, cultivation, puddling and application of wheat straw. Preliminary tests unveiled that volume of water required to fill the cracks constitutes a major component of the total depth of infiltrated water. The performance of various management practices in term of irrigation efficiencies, fruit yield and water use efficiency of eggplant followed the order of straw > puddling > cultivation control > control. The results also displayed a declining trend in water irrigation efficiencies, fruit yield and water use efficiency of eggplant with increasing length of furrow from 30m to 70m.

***Key words:*** Cracked soils, soil management practices, eggplant, irrigation efficiencies, water use efficiency

## Introduction

The national economic of Iraq can be raised by bringing more lands under irrigation. The expansion of irrigated lands without appropriate water management will not ensure crop production demands (Yigezu *et al.,* 2016). Furrow irrigation is one of the most popular methods of surface irrigation in different parts of Iraq. (Kumar and Singh, 2003) reported that proper management is of urgent need in view of increasing water demands, limited resources and groundwater contamination. It is observed that the main constraints on furrow irrigation are considerable loss of water through runoff and deep percolation (Reddy and Clyma, 1981). The problem of water loss via deep percolation is more profound or more problematic in Vertisoils. These groups of soils represent a vast crop production resource and account for a considerable portion of the intermountain valleys and the Mosul-Erbil-Kirkuk plains of Iraq (Muhaimeed, *et al.,* 2014).

These soils crack upon soil moisture loss and the formed cracks facilitate rapid transport of surface water into the subsoil via preferential flow (Dinka *et al.,* 2012).

Different approaches to improve the on-farm application efficiency of surface irrigation practices can be broadly categorized according to whether they modify the soil, water (application/scheduling) or design parameters (Raine *et al.,* 1996), (Yahya and Abdul-Razaq, 2017), (Mandal *et al.,* 2004), (Masood, T.K., 2015) and (Al-Omran, *et al.,* 2010) revealed thatthe performance of surface irrigation systems is a function of field design, infiltration characteristics of the soil, and the irrigation management practices.

(Islam *et al.,* 2004) reported that among nine soils management practices the hand hoe operation offered a better performance than trampling to reduce cracks with a width of 10mm. The findings of (Wopereis, *et al.,* 1994) revealed that puddling can reduce the non-capillary pore spacing, resulting in a closer packing of soil particles.

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Plant roots can perform various tasks to reduce cracking intensity via forcing the soil to be coherent and acts as a single mass when the soil starts to fail (Abernethy and Rutherfurd, 2001). Furthermore. (Wopereis, *et al.,* 1994), have noticed that shallow tillage reduced the preferential flow or crack bypass flow in undisturbed cores by (45-60%). The findings (Mousavi *et al.,* 2011) (24) elucidated that application of organic materials in soil could delay crack formation and its intensity.

Eggplant (*Solanummelongena* L.) is one of the Solanaceae plants and considered as one of the cultivated vegetable crops in many regions of the world including the Middle East Region (Sarhan, H, 2011). Additionally, it has a high nutritional value (Abu-Alaees and Al Baity 2017). In order to achieve high eggplant yield, an adequate water supply is required during the growing season (Pirboneh *et al.,* 2012). Accordingly, the current study was conducted with main objective of improving irrigation performance and yield and water use efficiency of eggplant grown in a cracked soil in Sulaimani Province via implementing some selected soil management practices.

## Materials and methods

### Study Site Description

The field experiments were conducted at the research farm of the Directorate Agriculture Research–Sulaimani, Iraq. It is located about 20km northeast of the Sulaimani city center. The geoposition of the experimental site is 35°22'4.75"N and is 45°37'47.45"E, lying 548m a.s.l.

On the basis of aridity index (AI) defined as the ratio of mean annual precipitation to potential evapotranspiration, the climate regime can be classified as semiarid (0.2 > AI < 0.5) (United Nations Educational, Scientific and Cultural Organization (UNESCO), 1979). The aridity index according this scheme is 0.23. Further, it can be classified as a temperate, dry summer, hot summer (Csa) according to the scheme proposed by Koppen.

According to soil taxonomy Soil Survey Staff, (Baillie, I.C., 200), Soil Survey Staff 1999), the soil at the experimental site is categorized as: fine clay, active, mixed, thermic, Typic Chromoxerets. The soil of the site is nearly free of rocks (clay = 40.17%, silt = 52.62%, sand = 7.21%, $EC_e$ = 0.57 $dSm^{-1}$). Furthermore, the soil has relatively a high potential to volume change, which is manifested by wide and deep crakes during the summer season.

### Preliminary Tests

Prior to conducting field experiments on a large scale, several sets of pot experiments were conducted to determine the potential of the investigated soil to volume change and cracking. Another test was also carried out to determine the percent of linear shrinkage of investigated soil according to (British Standards Institution. 1990).

Additionally, a plot experiment was conducted to evaluate the performance of some selected management practices (control, cultivation, puddling and wheat straw application) on reducing cracking index using small plots (2m × 2m) before extrapolating them to the field via implementing large scale experiments.

### Field Experimental Layout

The experiment was laid out in a completely randomized block design with three replications. Four treatments were applied with a total number of 12 experimental units or with 36 furrows. Each furrow of experiment 1 had a length of 30m with an average depth of 0.25m. The top width was 0.55m, while the side slope was 1:1. Further, the longitudinal slope was 0.015m/m. unless otherwise stated, the experiment furrows were blocked on the downstream ends.

Each experimental unit was composed of three adjacent furrows. The treatments encompassed:

T1 = Control

T2 = Application of chopped wheat straw at a rate of 0.6kg $m^{-2}$ buried at a depth of 5cm below the furrow bed surface

T3 = Hoeing (Shallow tillage of the furrow bed or cultivation)

T4 = Puddling during irrigation

### Planting and other Cultural Practices

Prior to transplanting, seeds of eggplant plant cultivar (Species: MELANZANA, Varity: VIOLETTA) were sown in a nearby nursery in form of four plots, each having an area of 5m$^2$ (2m × 2.5m) on February 20, 2017. Subsequently, the seedlings were transplanted into the furrows on May 27$^{th}$ in 2017. The seedlings were transplanted at the furrow crest at spacing of 0.60m on both sides of the ridges. The ridge top center spacing was 0.75m. The eggplant received a basal application of 25kg N and 225kg P in form of urea and single superphosphate, respectively. Weeds were removed manually three times in the season and irrigation water was applied during the growing season based on the proposed irrigation schedule.

It is commendable to mention that the experiment was repeated during the summer season of 2018. It was similar to those of 2017 except that the furrow length was 70 m instead of 30m. Further, the transplanting date was 25 May 2018 instead of 27 May 2017.

### Irrigation Schedule

The eggplant was irrigated whenever time 40% of available water was depleted. The soil moisture content was monitored gravimetrically by using a small worm type auger and the leaf appearance was used as an indicator for the time of irrigation. The source of irrigation was a nearby stream with an average EC of 0.85dSm$^{-1}$.

### Advance Time Measurement

The central furrow under each treatment was divided into a number of stations having equal distances between them by driving metal pegs into the soil at 3m interval along its length. In order to maintain a constant flow of water into the head of the furrow during the test period, a free flow V-notch weir was installed to supply water at a rate of 0.4 L s$^{-1}$. As the irrigation water was advanced down the furrow arrival times were recorded at the end of each rich using a stopwatch. The advance time was measured during the applied irrigation events.

### Performance Indictors

The performance of different management practices and irrigation techniques were evaluated by using: the irrigation adequacy (Amer and Daim 2011); irrigation application efficiency (Zerihun *et al.,* 1997) and distribution efficiency (Holzapfel, *et al.,* 1985).

### Crop Yield and Field Water Efficiency

The eggplant fruit were picked every 5-7 days and the total marketable yield was assessed. Additionally the following formula was used to calculate the field water efficiency James (James, L.G. 1988):

$$\text{WUE} = \frac{Y}{d} \times 1000$$

Where: Y = Crop marketable yield (t ha$^{-1}$)

d = Volume of applied water (m$^3$ha$^{-1}$)

WUE = Field water use efficiency (kg m $^3$)

## Results and Discussion

### General Aspects about the Cracking Characteristics of the Soil at Experimental Site along with the Specification of Furrow Irrigation System across the Region

Visual field observations indicated that summer shrinkage and subsequent winter swelling in the soil of the experimental site is a perennial process. The swell-shrink potential is manifested in form of cracking during the dry season. Soil cracking is a striking morphological feature of Vertisols. Constitute a considerable portion of the total geographical area of Iraqi Kurdistan region.

On average the cracks were 6.58 ± 0.55 cm wide and 80 ± 7 cm deep. The cracks fall in the deep class (Ahmad and A. Mermut, 1996). Among many criteria that are available to identify and characterize the potential capacity of the soil to volume change; percent of linear shrinkage was used as a criterion for this purpose. Laboratory tests indicated the percent of linear shrinkage is in the range of 10 to 12% it appears that the study soil is characterized by having of a considerable proportion of highly active clay minerals of the montmorillonite group which are responsible for its pronounced capability to volume change.

Albeit, there was no standard identification and classification of shrinkage and swelling potential of soils (Nelson and Miller, 1992), the study soil fell in the critical class (PLS > 8%) according to the classification scheme proposed by (Altmeyer 1955).

The results also indicated that the cracking index for the experimental site varies from as low as 0.4m to as high 1.2m with an average value of 0.65m. It is evident from the above results that the volume of water required to fill the cracks constitutes a major component of the total depth of infiltrated water.

These results emphasize on the fact that the soil of experimental site has a high capacity to recharge the soil profile and water table during water application from irrigation and rain. Additionally, the high surface area facilitates the water loss from the soil profile through evaporation (Ritchie and Adams, 1974).

This type of data can be considered as prerequisite information for selecting the appropriate management practices for sustainable agricultural production with minimum environmental degradation in highly cracked soil.

Although the furrow system is used for a variety of row crops, at present its use is confined mainly to vegetable crops like tomato, eggplant, lady finger, squash, cucumber, cowpea and melon, etc. The furrow length across the upper part of Iraq hardly exceeds 50m. In the view of the authors, the factors posing restrictions on furrow length are: fragmented sizes of farmer's land, small stream sizes, manual (none mechanized) farming and rocky soils, Further, The practice of tail water recycling is absent. This means that blocked end furrows are the dominant type. However, short furrows require a lot of attention, but water can be used efficiently.

### Preliminary Tests

Before initiating the main field experiments, a laboratory experiment was conducted to study the response of crack volume to soil compaction and soil moisture content of the soil of the experimental site Fig. 1. It was revealed that irrespective of degree of compaction the crack volume starts to stabilize at a soil water content of about 15%, which is close to the permanent wilting point of the investigated soil. It can also be observed that the water content at which cracks start to generate is soil bulk density dependent. The higher the soil bulk density the higher will be the soil water content at which cracks start to generate. Overall, crack starts to generate at a soil water content that exceeds the field capacity of soil (FC = 25.5%).

Based on the obtained data of Fig. 1 and from management point of view, it is recommended to avoid soil compaction on one hand and not allow the soil water content to drop substantially below the field capacity on the other hand. This implies by growing crops with small depletion fractions. Under these conditions, the risk of groundwater pollution can be largely avoided. It is commendable to indicate the data of Fig. 1 were obtained from a soil column experiment conducted in the laboratory exposed to open air.

Table 1 depicts the parameters of the infiltration under different soil management practices during the plot experiment and prior to conducting the main field experiments. As can be noticed in (Table 1) that the applied treatments were effective in reducing the intercept of the infiltration model in the following order: Puddling > Straw > Shallow tillage (hoeing) > Control.

It is worth mentioning that the intercept of the equations is representing the cracking index or the depth of water that must be applied before ponding initiation. The results also showed that, compared to the control, the percent of reduction in cracking index under puddling, straw, shallow tillage or cultivation treatments were 22.98, 14.86 and 9.46% respectively. The same conclusions were drawn when the three parameters of model were taken into consideration collectively. It is commendable to indicate that the cumulative infiltration at a given time does not depend only on the intercept, but also on the model coefficient and its exponent collectively.

**Table 1:** Effect of type of management on the component of infiltration rate.

| Treatment | $f_o$ | $f_c$ | $f_{average}$ | Equation |
|---|---|---|---|---|
| Control | 76.713 | 8.494 | 16.8 | $D=104.69+2.247\,T^{0.569}$ |
| Straw | 40.309 | 2.219 | 5.83 | $D=89.13+1.782T^{0.377}$ |
| Puddling | 43.430 | 1.564 | 4.55 | $D=80.64+2.074T^{0.349}$ |
| Cultivation | 40.352 | 7.613 | 12.98 | $D=94.79+1.019T^{0.660}$ |

It is obvious from the above results that the applied treatments were effective in reducing the cumulative depth of infiltrated water in general and, in particular, under the puddling and straw treatments. It is of vital importance to take benefit from these soil management practices to lower the risk of groundwater pollution.

### Advance Time as Influenced by Different Soil Management Practices

By plotting the time water arrives at various distances down the furrow against the distance under different soil management practices, advance curves were developed to describe the rate at which water moves down the furrow having a length of 30m Fig. 2. The average surface irrigation water flow advanced faster and less time was needed under all the applied treatments compared to the control. It was also noticed that the advance trajectories of the three treatments did not differ much from each other. The fastest advance time to reach the end of the

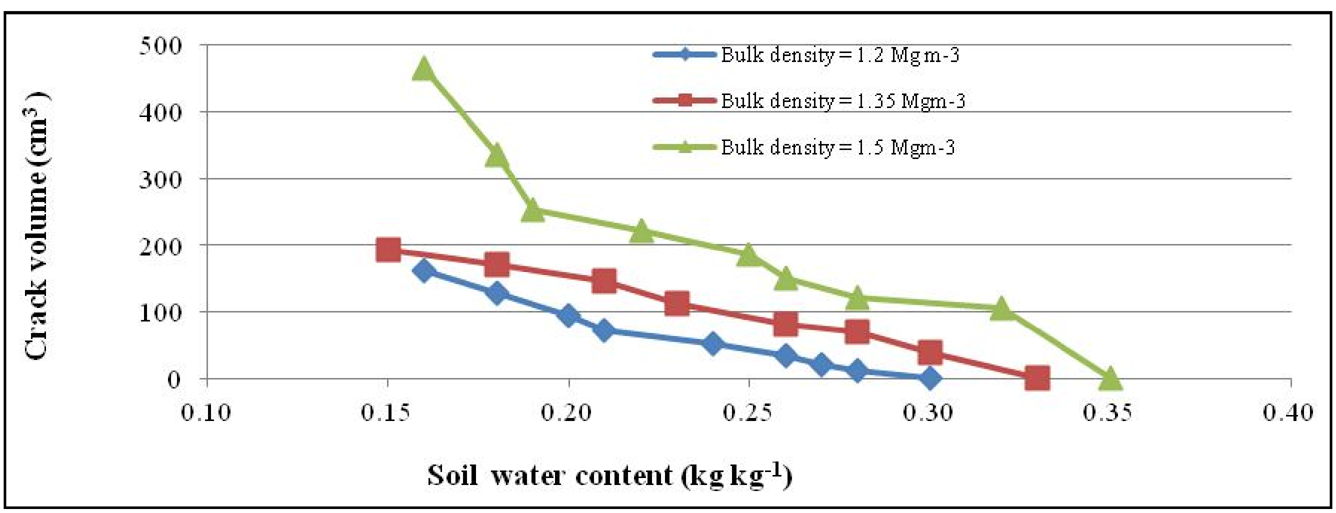


**Fig. 1:** Variation of crack volume with soil moisture loss under different degree of soil compaction

furrow was observed for the straw treatment and the puddling the next fastest.

Although, successive irrigations presumably act to consolidate the soil, reducing impedance and increasing the rate of irrigation advance, but this effect was not profound during successive irrigation

Fig. 2 Indicate that wave-front advance along the furrows is quasi-linear under straw, puddling and shallow tillage. On the other hand, the advance curve of the control treatment can be described by a power function model.

Overall, waterfront under the control treatment reached the end of the furrows in about 50 minutes, while, less than this amount was needed for water front to reach the end under treatments respectively. The time required for water to advance down the control furrow was about 1.5 times longer than the time required under the rest of the treatments.. However, for efficient irrigation, advance must be rapid throughout the length. Generally, slower advance times can be observed during the late stage of water advance. When water advances through the furrow some of it infiltrates into it. This causes both flow rate and flow velocity to decrease, so the closer the water front gets to the end of the field, the longer it takes to cover a unit of distance

Additionally, the results indicated the advance curves exhibited similar trends in the field experiment in which the length of the furrows was 70 m Fig. 3. The exception is the time required for water to advance down the control furrow was about 2 times longer than the time for the remaining treatments.

These outcomes indicate that applied treatments under the conditions that prevail in the study region lead to a shorter advance time in comparison to control treatment.

### Irrigation Efficiencies

Results of the study showed that the with 30m furrow length, the highest application efficiency of 76.13% was obtained under straw treatment, whereas the lowest application efficiency of 70.45% was obtained with control treatment Fig. 4. A none-significant difference observed among straw, puddling and cultivation practices. Dunnett's–test indicated that with no exception the application efficiency all the applied treatment differed high significantly ($P \leq 0.01$) from that under control

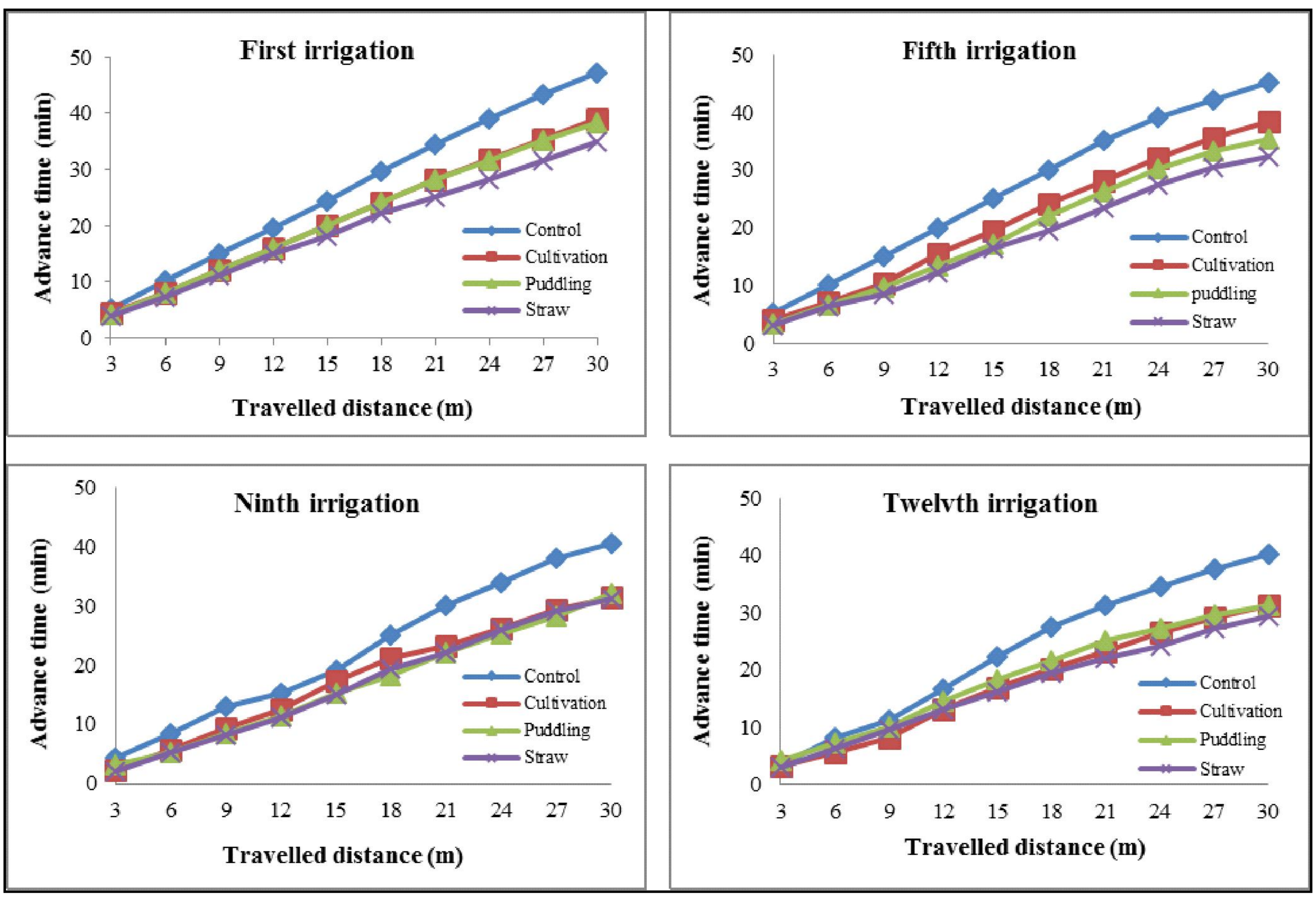


**Fig. 2:** Advance time versus elapsed time for the different management for 30 m length

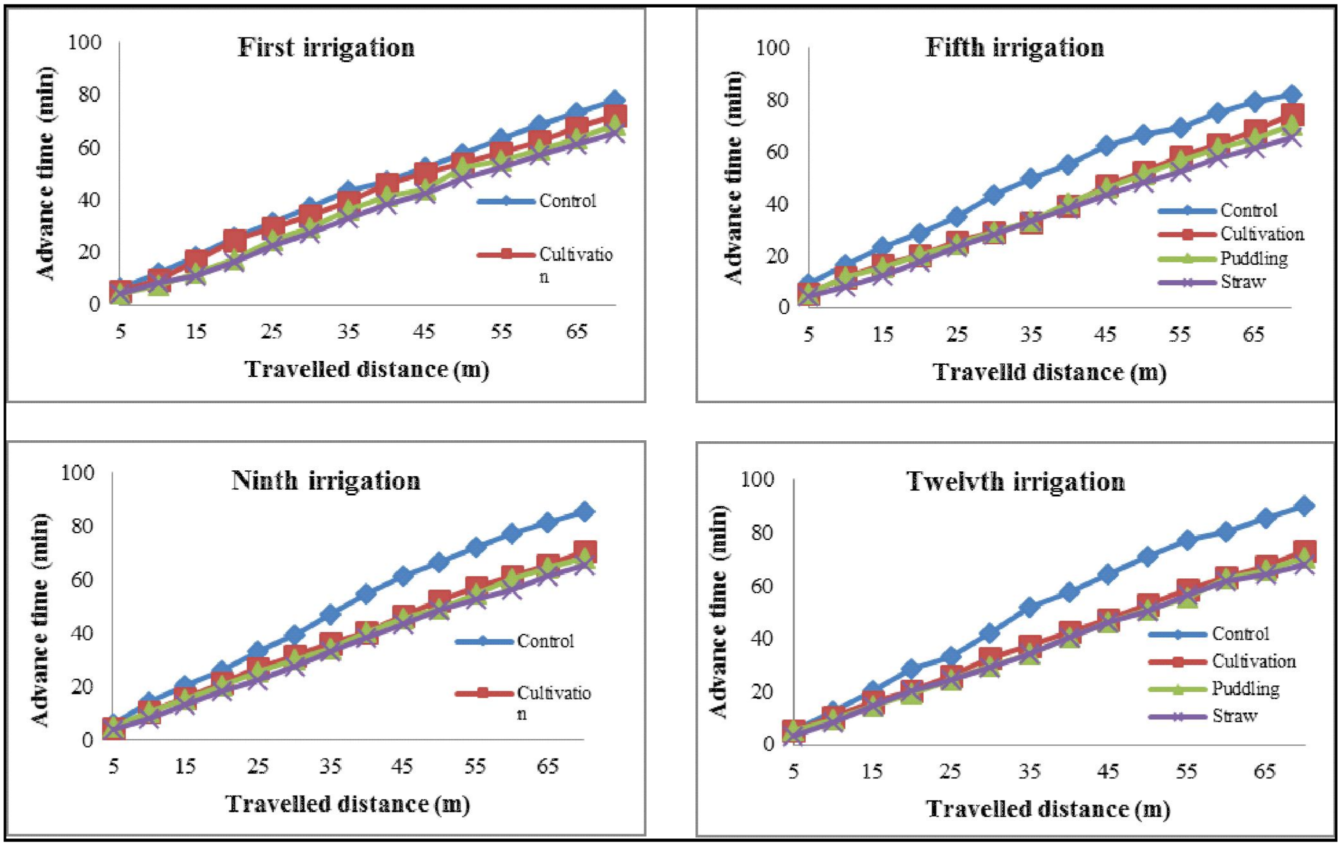


**Fig. 3:** Advance time versus Elapsed time for the different management for 70 m length

treatment.

It was also noticed in Fig. 5 that the applied treatment

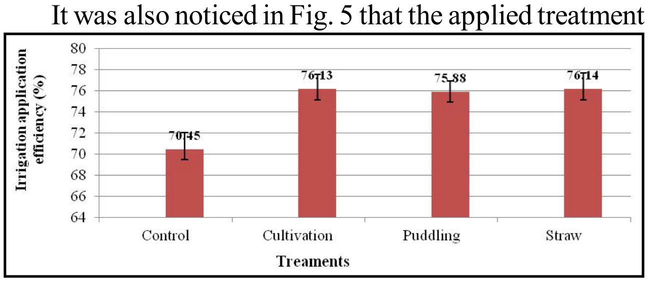


**Fig. 4:** Irrigation application efficiency as influenced by different soil treatments when the furrow length is 30 m

in the experiment with 70m furrow length exhibited similar trends. The highest Ea of 74.17% was obtained with the straw treatment followed by cultivation, puddling and control. Additionally, it can also be observed that the percent of increase in Ea due to implementation of any of these three management practices were about 10 and 8% for furrows with lengths of 30 and 70m respectively.

Comparison of irrigation efficiency under different management practices indicated that reducing field length is an effective measure for improving irrigation efficiency and for reducing percolation rate below the root zone Fig. 6. Studies have shown that shortening the field length by one-half can reduce percolation by at least 50 percent (Bali et al, 2010). This in not consistent with (Yegezu *et*

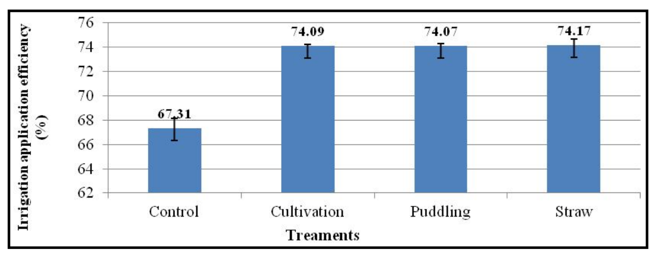


**Fig. 5:** Irrigation application efficiency as influenced by different soil treatments when the furrow length is 70 m

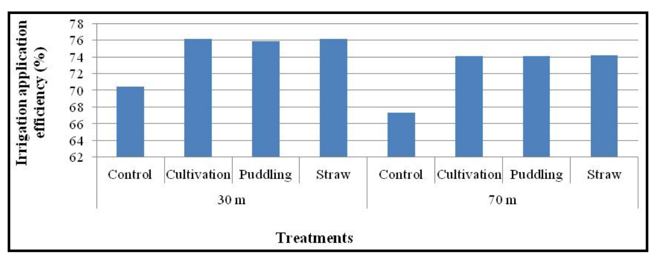


**Fig. 6:** Irrigation application efficiency as influenced by different soil managements and furrow length

*al.,* 2016) who reported that the efficiency of irrigation for open ended furrows efficiency increased from 24.6 to 34% when the furrow length increased from 16 to 48m. They also noticed that open ended short furrows were the major source of water loss through surface runoff.

Fig. 7 depicts the effect of different management

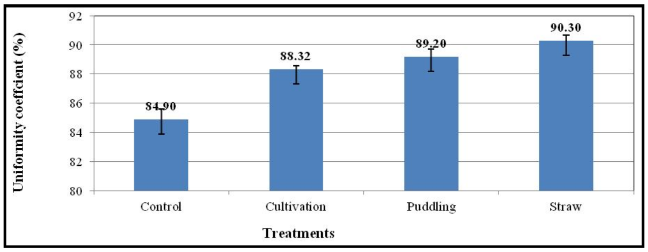


**Fig. 7:** Uniformity coefficient as influenced by different soil treatment for furrows having lengths of 30m.

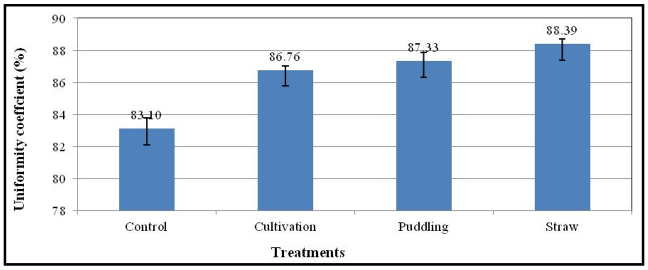


**Fig. 8:** Uniformity coefficient as influenced by different soil treatment for furrows having lengths of 70m

practices over 12 successive irrigations on coefficient of uniformity when the length of the furrows was 30m. As can be seen in Fig. 8 Straw treatment recorded the highest coefficient of uniformity of 90.3%%, whereas control treatment registered the lowest value of 84.90%. The Coefficient of uniformity decreased in the order straw > puddling > cultivation > control. Dunnett's-test unveiled that each of applied three treatments differed high significantly ($P \leq 0.01$) from the control treatment.

By contrast, there was no significant difference in coefficient of uniformity between these three treatments.

It is noteworthy that the applied treatments with 70m length followed a pattern similar to those with 30m length in term of coefficient of uniformity Fig. 8. For instance, the straw and control treatments offered the highest and lowest values for Cu respectively. In the meantime, the effect of the applied treatment on increasing Cu is less profound with 70m furrow length compared to 30m furrow length. Similar to Ea, values of Cu decreased with an increase in furrow length under all the treatments Fig. 9. Irrigation runs that are too long result in overwatering at the top of the furrow (Waskom, R.M. 1994). It seems from these experiments that significant improvements in irrigation performance could be obtained via the adoption management practices that are suitable to the farm's environmental and management constraints. Overall, the results indicated that the irrigation adequacy more than 70 % in most cases.

## Crop yield and Water Use Efficiency as Affected by Different Management Practices

Comparison of average fruit yields under different management practices with a 30m furrow length indicated that the straw treatment offered the highest fruit yield

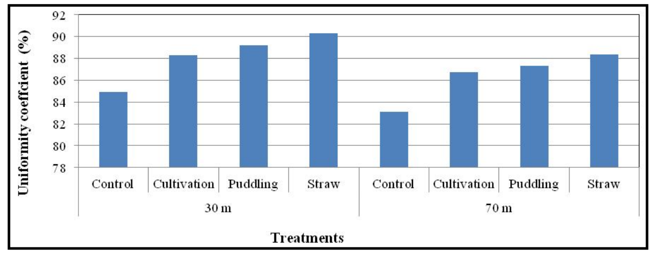


**Fig. 9:** Uniformity coefficient as influenced by different soil treatment and furrows length.

(60.43 t $ha^{-1}$) and the control has the lowest fruit yield (43.91 t $ha^{-1}$) (Fig. 10). Residue incorporation results in more microbial activity and more water availability than its removal. Accordingly, if residues are managed properly, it can warrant improvements in soil properties and sustainability in crop productivity (Mandal *et al.,* 2004).

Albeit, the three treatments did not differed from each other significantly, each differed high significantly ($P \leq 0.01$) from the control treatment. There were significant increases in marketable yield of over 38, 36 and 29% by adopting straw, puddling and cultivation practices respectively as against the control treatment irrigation when the furrow length was 30m.

Similarly, it was observed that the fruit yield under the straw treatment and with 70m furrow length was superior to those under the other practices as it resulted in a yield of 49.84 t/ha compared to the control treatment Fig. 10. The increase in yield was associated with increased soil moisture content. The improved soil water availability resulted in greater plant growth and crop yield (Ne Smith *et al.,* 1987)

These results confirms the previous the findings (Ayas, S. 2017)., who observed that the eggplant yield varied between 18 to 62 t $ha^{-1}$. In another study by (Colak *et al.,* 2015), it was observed that full irrigation treatment with 3-day interval under surface drip irrigation produced the highest yield (78.5 t $ha^{-1}$) and the lowest yield was obtained with 6-day interval under subsurface drip irrigation (40.9 t $ha^{-1}$). Similar yielding data were reported by (Maghfoer *et al.,* 2014), who have noticed that cultivation of eggplant with 3 main branches has resulted

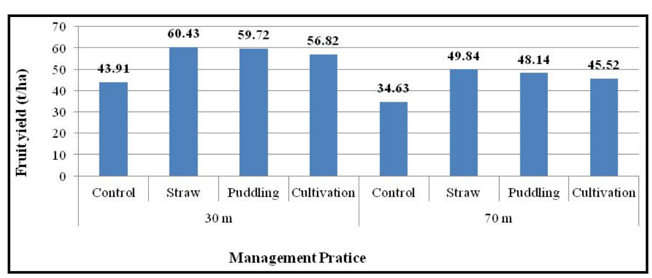


**Fig. 10:** Total fruit of eggplant as influenced by different soil management practices and furrow length

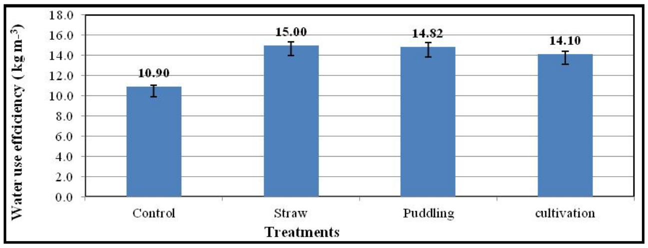


**Fig. 11:** Eggplant water use efficiency as influenced by soil management practices with furrow length of 30 m.

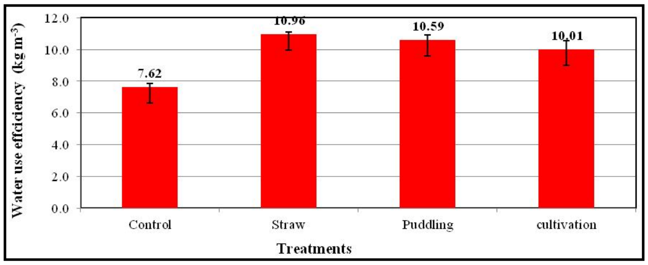


**Fig. 12:** Eggplant water use efficiency as influenced by soil management practices with furrow length of 70 m.

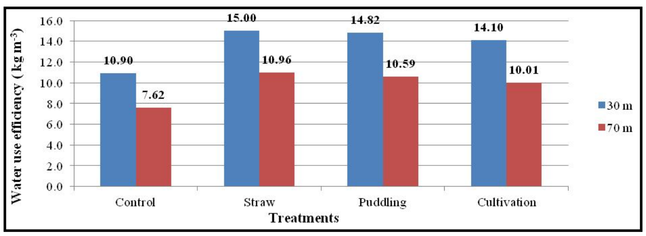


**Fig. 13.** Eggplant water use efficiency as influenced by soil management practices and furrow length

better growth and fruit yield than 1 and 2 main branches, 50.85, 47.91 and 30.79 t ha$^{-1}$ respectively, In contrast, They are inconsistent with the findings of (Rahman *et al.,* 2011), who observed that the highest yield per hectare (29.84 t ha$^{-1}$) was recorded in the cultivar Nayantara and the lowest yield (10.50 t ha$^{-1}$) was recorded in the cultivar Dhundhul.

Factors like variety, degree of maturity, climate, protection and management factors are affecting variability in eggplant fruit yield. For instance (Adamczewska-Sowisk and Krygier. 2013), reported that an eggplant is a thermophilic plant and thermal conditions favored eggplant growth. Yields can reach 3.5–4.5kg m$^{-2}$ for short cycle and 11.5–13.0kg m$^{-2}$ for long cycle in greenhouse cultivation (FAO. 2017). However, the performance of various management practices with both furrow lengths followed the order of straw > puddling > cultivation > control.

It can also be noticed from Fig. 10 that fruit yield under the same management tended to decrease with an increase in furrow length due to decreased water availability with an increase in furrow length.

On average, the crop consumed 504 and 568 mm during the whole growing seasons for the experiments where the furrow length was 30 and 70m respectively. No rainfall was received during these periods. These results are in accordance with the amount of irrigation water applied from previous studies. (Ertek *et al.,* 2002) reported that irrigation water applied to eggplants varied between 452 and 696mm. By contrast, (Kirnak *et al.,* 2002) observed the applied water to eggplant were in between 905 and 1373mm in southeastern part of Turkey.

As can be seen in Fig. 11 and 12, the average water use efficiency (WUE) was highest under straw treatment (15kg m$^{-3}$) when the furrow length was 30m, which was significantly superior to the other three treatments. This statement is also true for experiment with a furrow length of 70m. In this experiment, the straw treatment resulted in maximum water efficiency treatment (10.96kg m$^{-3}$).

**Table 2:** Summary of Dunnetts test and percent of increase in water use efficiency of eggplant due to different treatments over control in the field experiment.

| Furrow length (m) | Treatment (Ti) | Average water use efficiency (kgm$^{-3}$) | Absolute difference \|Ti-T1\| | Percent of increase with respect to control = [100 \|T1-Ti\|] /T1 ] |
|---|---|---|---|---|
| 30 | Control(T1) | 10.90 | 0.00 | 0.00 |
| | Straw(T2) | 15.00 | 4.10 | 37.62 |
| | Puddling(T3) | 14.82 | 3.92 | 35.99 |
| | Cultivation(T4) | 14.10 | 3.20 | 29.39 |
| | Dunnett D(0.05) | 0.70 | | |
| | Dunnett D(0.01) | 0.97 | | |
| 70 | Control(T1) | 7.62 | 0.00 | 0.00 |
| | Straw(T2) | 10.96 | 2.25 | 25.89 |
| | Puddling(T3) | 10.59 | 1.88 | 21.59 |
| | Cultivation(T4) | 10.01 | 1.30 | 14.97 |
| | Dunnett D(0.05) | 0.80 | | |
| | Dunnett D(0.01) | 1.12 | | |

When the results concerning WUE are compared with the findings of other researchers, on can conclude that they are consistent with most of them. For instance, (Ayas, S. 2017) obtained a value of 13.14kg m$^{-3}$ for WUE under full irrigation of eggplant. Further, he demonstrated that the values of WUE are affected by a host of factors, including, climate, variety choice, soil structure, efficient use of water, etc.

The results presented in Table 2 also revealed that water use efficiency under straw, puddling and cultivation treatments was increased by 37.62, 35.99 and 29.39% as compared with control when the furrow length was 30 m. concomitantly; the percent of increase in water use efficiency was 25.89, 21.59 and 14.97% as compared with control when the furrow length was 70m.

The results displayed in Fig. 13 revealed a declining trend in water WUE with increasing length of furrow from 30m to 70m. Further, Dunnett's test indicated that there is a high significant difference between control and straw as well as between control and each of puddling and cultivation (Table 2).

It is of vital importance to take benefit from the applied soil management practices, in general and applying straw in particular, to improve eggplant yield, its water efficiency and to reduce the risk of groundwater pollution in cracking soils. Further, it can also be concluded that reducing field length is an effective measure for improving irrigation efficiency, eggplant yield and its water use efficiency.

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