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Perspective of drip irrigation in maize: A review

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Abstract
Maize has become a staple food in many countries of the world, with the total production of maize surpassing that of wheat or rice. The efficient use of water by modern irrigation systems is becoming immensely important in arid and semi-arid parts of the country with limited water resources. Drip-irrigation has increasingly applied in maize (*Zea mays* L.) production in sub-humid regions also. It is critical to quantify irrigation requirements during different growth stages of maize under diverse climatic conditions. Maize is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions in different parts of the world. Globally, maize is known as the queen of cereals because it has the highest genetic yield potential among different cereal crops. It is cultivated in many countries having a wider diversity of soil, climate, biodiversity, and management practices.

Keywords: Adaptability, agro-climatic, biodiversity, drip irrigation

Introduction
Water play a vital role in crop production and in the arid and semi-arid areas, water availability is the main ground for reducing the crop production. Day-by-day water use is increasing and that's why paves the way to improve the water use efficiency. Approximate 85% water is used for crop production and by efficient water management we can maximize the water use efficiency (Mahmoud *et al*., 2016). Maize is a C_4 plant and is grown for both grain as well as fodder purpose. Maize crop requires 500 to 800 mm water from sowing to harvest (growing period) (Brouwer and Heibloem, 1986) [3]. Under water scarcity, both maize yield as well as quality is affected. The demand for fresh and processed food maize is increasing day-by-day, with the challenge of higher water productivity. Zwart and Bastiaansen, 2004 [22], gave various factors like no. of irrigations, along with environment and fertilizer application accountable for increasing the water productivity. According to them by reducing the irrigation application, water productivity can be improved.

By increasing the water productivity and irrigation efficiency, we can improve the yield of crops (Fatih *et al*., 2009). The effective supply of water and nutrients to plants through drip irrigation not only save the water but also increase the crop yield (Tiwari *et al*., 2003; Deshmukh and Hardaha, 2014). Drip irrigation system is the only way to come out of the water scarcity problem. More root length density is observed in the sub-surface drip irrigation than in the surface drip below 30 cm (Al-Omran *et al*., 2004). Drip irrigation has many benefits; it saves water, labour and machinery (Feleafel and Mirdad, 2013; and Vijayakumar *et al*., 2010).

Effect of drip on maize morphological growth
Some studies reported that water stress significantly affected maize plant height and deficit irrigation typically resulted in shortened plants (Karasu *et al*., 2015; Aydinsakir *et al*., 2013; Çakir, 2004) [12]. The ear length and diameter increased due to an increased applied irrigation amount. According to Moosavi (2012), maize ear diameter is closely associated with the assimilates produced by photosynthesis, which varies markedly with water stress.

Different drip irrigation levels pose a significant difference in above-ground biomass in raised bed planted corn. According to Bozkurt *et al.*, 2011 [2], Irrigation levels had a statistically significant effect on the fresh (102.4 t ha^{-1}) and dry above-ground biomass (31.8 t ha^{-1}) production of corn (P< 0.01 level) in I_{120} treatment.

Effect of drip on maize physiological growth
The maximum LAI observed at flowering for the fully irrigated treatment was 5.83 and 6.05 m^2. Under deficit treatments, on average the reduction in maximum LAI ranged between 7.6 and 29.6%. Farré and Faci (2006) revealed that the first process to be affected by water deficits is leaf expansion.

Effect of drip on maize production

Abd El- Wahed and Ali, 2013 proved that drip irrigation has maximized grain yield along with water use efficiency as compared to sprinkler irrigation. Aydinsakir *et al.* (2013) suggested that 1000 grain weight reduced owing to soil water deficits and low transition of photosynthesis matter and assimilates to kernels similar to Çakir (2004) and Karam *et al*. (2003), while some studies have reported that irrigation water amounts do not cause a significant difference in grain weight (Elzubeir & Mohamed, 2011; Yazar *et al*., 2009).According to Elzubeir and Mohamed (2011),the Irrigation interval has more impact on yield components while irrigation amounts do not affect the yield components.

Katerji *et al*. (2008) accounted that the critical growth stages for water deficits include the flowering stage (tasseling, silking, and pollination) and grain filling. The differences in the yield components were significant and deep surface drip line has more 100- kernel weights than the surface drip line (Douh B. and A. Boujelben, 2011) [5].

The number of grains per row decreased with the decrease in irrigation water amount. 30 and 20 mm water application depth was insufficient to maintain a wet soil profile, and grain yield reduced from 23 -40 percent as compared to 60-40 mm water application. According to Ogretir (1993), 1000 grain weight decreased due to water deficit application at the flowering stage.

Wu *et al.*, 2017 [20] experimented to study the effect of drip irrigation and drip fertigation on yield formation and water use efficiency of maize and suggested that drip fertigation significantly increased grain yield by 27% and 9% as compared to conventional and drip irrigation treatment.

Yield components *viz*. cob diameter, grain number per cob and 1000-kernel weight were highest in drip irrigation I_{120} treatment as compared to irrigation at 20, 40, 60, 80, and 100 treatments (Bozkurt *et al.,* 2011) [2].

Karasu *et al.,* 2015 [12] experimented to evaluate the effect of drip irrigation levels on grain yield and observed higher no. of row per ear, grains per row, grain per ear, and ear per plant in I_{125} treatment.

Effect of drip on maize quality

Ertek and Kara (2013) reported that deficit irrigation levels affected crude protein content, and it varied between 10.63 - 11.25 percent.Esmailian*et al*. (2011), Farhad *et al*. (2013), and Aydinsakir *et al*. (2013) worked on different maize cultivars and irrigation water levels gave statements that the grain protein contents were significantly influenced by different irrigation levels. According to Farhad *et al*. (2013), the maize grain oil contents were significantly affected by different irrigation water levels similar to Esmailian *et al*. (2011). Cultivar and experimental conditions may be the cause of these differences. Ogretir (1993) who worked with similar subjects reported that irrigation water amounts affected the hectoliter weight statistically. In general, deficit irrigation levels adversely affected hectoliter weight (Kuscu, 2010).

Higher protein and starch content was observed under surface drip treatment as compared to conventional furrow irrigation method in maize (Ghamarnia *et al*., 2013) [9].

Effect of drip on water productivity

An understanding of water use efficiency (WUE) was essential for evaluating the field crops in semi-arid regions where irrigation water was a limiting factor (Johnson and Henderson, 2002) [11]. Under a limited water supply situations, the goal may be to achieve the highest possible WUE. High WUE is attainable without significant yield penalty (application depth of 50 and 40 mm), offering opportunities for improving the farm-level water use and sustainable water development by Geneille and Wang (2017). Conventional irrigation had the lowest WP than drip due to higher water amounts applied under the conventional method. (Mahmoud *et al.*, 2016).The drip irrigation at 0.35 m had a higher WUE (Douh B. and A. Boujelben, 2011) [5]. WUE values up to 1.62 kg m^{-3} reported by Kuscu and Demi, 2013. El –Meseery, 2003 revealed that under sandy soils, drip irrigation saved 20-25 percent of the water applied. Abdel- Hafez *et al*., 2001, reported that drip irrigation in clay soil increased crop and field water-use efficiency of maize crop by 9.52 and 35 percent, respectively than to furrow irrigation system.

Effect of drip on maize root distribution

With drip systems since it is widely believed that drip irrigation may limit the volume of wetted soil and thus the extent of root development. Under different irrigation methods, understanding of plant root length density is an important aspect. In drip irrigation, root length density and specific root length decreased with increase in soil depth. Gao *et al.*, 2010studied that the crest horizontal spread of maize roots occurred in the 16-22 cm layer of the soil and root depth increased with the increase in soil depth.

Phene *et al.*, 1991 [16] experimented to analyze the root distribution of sweet corn under the high-frequency surface (S) and subsurface (SS) drip irrigation. On the surface, 30 cm (S- plots) higher root length density was observed while the SS plots had greater root length density than the S- plots below 30 cm depth.

Plant water uptake patterns play an important role in the success of drip irrigation system design and management. Here the root systems of corn were characterized by their length density (RLD) and root water uptake (RWU). RLD exponentially decreased with the deepening of soil layers at all horizontal distances from the dripline, which was in accord with Zuo *et al.* (2013) [21].

Measurement of root biomass does not provide information on the active root-surface area or root length because of the potential bias introduced by the inclusion of large, inactive roots (Box and Ramseur, 1993) [1]. Due to the growth of more brace roots, a shallower and denser root system developed under the low application rate. For the root length density and specific root length of maize decreased with an increase in soil depth under drip irrigation as a result of its root water uptake (RWU) also decreases from the deeper layer of soil. These differences in root distribution may due to micro-drip irrigation.

Soil Physico-chemical properties

A field study was carried out by Jun-li and Yue-hu (2009) in maize under drip irrigation and observed a decrease in bulk density while a significant increase in saturated water content. Soil organic matter content reduced, while total nitrogen, total phosphorus, and total potassium increased after cropping and drip irrigation.

A field experiment was conducted by Wu *et al*. 2017 [20] in China from 2012-2015 to study the effect of drip irrigation on soil physical properties and observed an increase in soil moisture under drip irrigation in maize.

Soil biological properties

Jun-li and Yue-hu (2009) concluded that the population of bacteria, actinomycete, and fungi increased significantly and tended to distribute homogeneously in a 0-40 cm soil profile. They observed an increase in urease as well as alkaline phosphatase activity indicating improvement in the microbial load in 0-40 cm soil profile.

Conclusion

In regions where water scarcity exists, irrigation managers should adopt the deficit irrigation approach to achieve sustainable crop production. DI regime achieved irrigation water savings up to 40% compared with 1.25 × Epan. Because the grain yields of maize grown for silage was not lower than those grown for grain, this can be a solution for gaining profit if the prices of silage are comparatively lower or the production is too high compared with the demand at some moment.

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