Influence of deficit irrigation schedules on nutrient uptake of maize hybrid under drip system

A Bharathi, T Ragavan, V Geethalakshmi, A Rathinasamy and Dr. R Amutha

Abstract
A field experiment was conducted during summer 2017 on sandy clay loam soil at irrigated upland farms of Tamil Nadu Agricultural University, Coimbatore to study the effect of deficit irrigation practices through drip system on nutrient uptake of maize crop. In the present study, PRD and deficit irrigation (DI) concepts (creation of soil moisture gradient) were implemented through alternate deficit irrigation (ADI) at two levels of irrigation having full and partial application at 60, 80 per cent, and four critical stage based PE as well as ET, based levels using drip system, comprised of seven irrigation levels. Higher growth and grain yield (75711 kg ha⁻¹) was recorded with plots irrigated with CDI at IW/CPE of 0.75 due to superior growth and higher nutrient uptake. Application of 80 and 60 per cent ET: as ADI produced next better yield and uptake among the deficit practices which was on par with a regulated deficit irrigation of 80 per cent as PE based approach.

Keywords: maize, deficit irrigation, NPK uptake and yield

Introduction
Water is one of the most precious and heavily scrutinized natural resource worldwide. Particularly in arid regions and in parts of the world that have limited water resources improving agricultural water use efficiency is vitally important. Innovative irrigation solutions must address the water scarcity problems affecting arid countries. Advanced irrigation technologies, such as drip and sprinkler irrigation, are more efficient than traditional surface methods to achieve higher crop and water productivity (Sivanappan, 1998) [13].

Deficit (or regulated deficit) irrigation is one way of maximizing the water use efficiency (WUE) for higher yield per unit of irrigation water applied. The goal of deficit irrigation (DI) is to increase crop WUE by reducing the amount of water at irrigation or by reducing the number of irrigation events (Kirda, 2002) [8]. Under DI, crops are deliberately exposed to water stress, which may consequently lead to yield reduction (Prichard et al., 2004) [11]. Drip irrigation has been practiced for many years for its effectiveness in reducing soil surface evaporation, increasing the crop yield and WUE (Sivanappan, 2004) [14]. Now it has been widely used in horticultural and wide-spaced agricultural crops to tackle the problem of water scarcity. In addition to DI, Partial Root zone Drying (PRD) is also a promising practice for inducing stress tolerance in some agricultural and horticultural crops (Gencoglan et al., 2005) [6]. The DI and PRD systems require high management skills. Micro-irrigation technology facilitates the application of DI and PRD.

Maize is a heavy feeder. Among the plant nutrients, nitrogen is the most important element for plant growth and development. High yielding maize hybrids, with very high biomass production, extracts higher amounts of mineral nutrients from the soil than by other major cereals like rice or wheat. It requires high quantities of nitrogen during the period of efficient utilization, particularly at 25 days after sowing and pre-tasseling (40 days after sowing) stages for higher productivity (Bravo et al., 1995) [1]. Keeping all this in view, this research was undertaken to study the uptake of NPK under various levels of deficit irrigation as implemented through drip system.

Materials and Methods
Field experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, to study the effect of varying deficit irrigation regimes in maize under drip irrigation system during summer, 2017. The experimental soil was texturally classified as sandy clay having 25.2 per cent field capacity, 12.5 per cent permanent wilting...
point and has 1.36 (g cc⁻¹) bulk density. Soil has pH value of 7.95, organic carbon content of 0.36 per cent and EC of 1.55 dsm⁻¹. The available status of nitrogen in the soil was low (264 kg ha⁻¹), with medium phosphorus (18.5 kg ha⁻¹) and high in potassium (378 kg ha⁻¹). The experiment was laid out in a randomized block design and the treatments were replicated thrice. Treatments comprised of seven irrigation levels through drip (Table 1). Drip irrigation system was operated once in three days and irrigation was applied as per the treatments based on PE and ETc levels.

Table 1: Treatment details

<table>
<thead>
<tr>
<th>T1</th>
<th>Conventional Irrigation at IW/CPE of 0.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>Irrigation at 80 % PE</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at 80 % ETc</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at 60 % PE</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at 60 % ETc</td>
</tr>
<tr>
<td>T6</td>
<td>80 and 60% PE as ADI [ADI – Alternate Deficit Irrigation]</td>
</tr>
<tr>
<td>T7</td>
<td>80 and 60% ETc as ADI</td>
</tr>
</tbody>
</table>

The experimental field was thoroughly ploughed. Beds were formed in the dimensions of 120 cm width, 30 cm furrow and 15 cm height. Buffer channels were formed to control the lateral seepage of water from one plot to another. The plot size was 7.2 x 4.5 m, accommodating six rows of crop. Maize hybrid COHM-6, was used for the experimental study. Seeds were hand-dibbled at the rate of one per hole. Paired row spacing of 120 + 30 x 60 cm was followed. Sowing irrigation was uniformly given to all treatments.

Water requirement (Litres per day or Lpd) or ETc= CPE x Kp x Kc x Wp x S,

Where, ETc= crop evapotranspiration, CPE = cumulative pan evaporation (mm), Kp= pan factor (0.8) (Vijayalakshmi, 2003), Kc= crop coefficient, Wp= wetting area percentage (80%) (Veeraputhiran, 2000), S = Crop spacing (0.60 x 0.25 m for maize).

Irrigation water was pumped from the water source and conveyed to the main line of 63-mm outer diameter (OD) polyvinyl chloride (PVC) pipes after filtering through sand filter. In the main line, venturi was installed for fertigation. From the main, sub-mains of 40 mm OD PVC pipes were drawn, and from the sub-main, laterals of 12-mm low linear density polyethylene (LLDPE) pipes were installed at an interval of 1.2 m. Each lateral was provided with individual tap control for imposing respective irrigation schedules. Along the laterals, inline drippers with a discharge capacity of 4 L hr⁻¹ were spaced at 0.4 m. Single lateral was used for a paired row of maize. Sub-mains and laterals were closed at the end with end cap. After installation, trial run was conducted to assess mean dripper discharge and uniformity coefficient. This was taken into account while fixing the irrigation water application time. During the irrigation period an average of 90--95% uniformity was observed. The recommended dose of fertilizer was applied as N: P₂O₅:K₂O @ 250:75:75 kg ha⁻¹. All the package of practices was carried out as per recommendation of CPG (2012) [2].

All the relevant biometric observations on growth parameters were recorded at periodic interval of the crop growth stages viz., 30, 60 DAS and at harvest stage. The yield and yield attributes of maize were recorded as per the procedure. The plant samples were collected for estimating DMP at harvest stages were used for nutrient analysis. The oven dried samples were powdered and utilized for estimating the uptake of N, P and K of crop as per standard procedure. The uptake values obtained as percentage in the analysis were computed to kg ha⁻¹ by multiplying with corresponding total dry matter production. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

**Results and Discussion**

The results obtained from the present study as well as discussions have been summarized under following heads:

**Growth attributes**

At harvest, taller plants with more leaves and thick stems was recorded from plots irrigated with 80 and 60 per cent ETc, as alternate deficit irrigation (ADI), which was comparable with regulated deficit of 80 per cent PE (Table 2). It is due to optimal availability of soil water throughout the cropping period, which vigorously induced the vegetative development of the plants. The higher availability seems to have promoted development of morphological structure by virtue of multiplication of cell division and expansion (Kang et al., 2000; El-Hendawy et al., 2008) [7,3]. Dry matter accumulation was highly correlated with soil moisture and increased as crop grew. It was mainly due to seasonal rainfall contribution, in all the treatments, which encouraged the plant growth and kept then stress free. Pandey et al. (2002) [9] and Farre and Faci, (2009) also expressed similar views in these lines.

**Yield attributes and yield**

Water stress significantly affected the yield components and most affected was kernel number and weight (Garrity et al., 1983) [5]. However, application of alternate deficit irrigation as 80 and 60 per cent ETc based produced heavier cobs with more grains row⁻¹ of longer corn embedded with more grain rows corn⁻¹, which is comparable with application 80 per cent PE as regulated deficits (Table 2). The mobilization of carbohydrate reserve in the stem and leaf sheath is a key factor for grain filling and contribution to grain weight (Zhang et al., 1998) [16]. This process was affected due to severe water stress and resulted in low grain weight. The results of this study also indicated that the lowest grain weight was obtained under severe water stressed treatments ie. 60 per cent PE based irrigation.

ADI treatments maintained grain yield as that of conventional drip irrigation at IW/CPE of 0.75 and the reduction was very little compared to the same. This is mainly due to favourable soil moisture during the growth period and better root development under alternate wetting and drying practice. Moreover, better root development under ADI may be attributed to good soil aeration and increase in microbial activity than other treatments. Payero et al. (2006) [10] found good linear relationships between yield and irrigation water applied in maize subjected to deficit irrigation treatments.

**Nutrient uptake**

Deficit irrigation imposed through drip system had significant effect on N, P and K uptake at different growth stages of maize (Fig 1). In general, uptake was found to be maximum at harvest for all nutrients. The higher NPK uptake compared to other treatments was observed under CDI at IW/CPE of 0.75. This might be due to availability of favorable soil moisture throughout the crop growth which promote plant growth positively and consequently accumulation of more DM and nutrients. This was found to be in agreement with Yazar et al. (2002) [15] and Sampathkumar (2003) [12]. Full irrigation
registered higher values for NPK uptake due to maximum production of dry matter, with better root development. Under severe stress (60 percent irrigation based on PE approach), P and K uptake reduced. Simulation of alternate wetting and drying through ADI improved the root proliferation and enhanced the nutrient uptake by the crop, whereas severe stress damaged the root system and reduced the absorptivity to nutrients.

Table 2: Effect of deficit irrigation practices on growth and yield attributes with grain yield of maize hybrid.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>DMP (kg ha⁻¹)</th>
<th>Rows per cob (No.)</th>
<th>Grains per row (No.)</th>
<th>Cob weight (g)</th>
<th>Grain yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ – CDI at IW/CE of 0.75</td>
<td>282.4</td>
<td>17728</td>
<td>14.0</td>
<td>37.6</td>
<td>127.6</td>
<td>7571</td>
</tr>
<tr>
<td>T₂ – Irrigation at 80 % PE</td>
<td>276.0</td>
<td>16780</td>
<td>12.8</td>
<td>35.2</td>
<td>117.4</td>
<td>7093</td>
</tr>
<tr>
<td>T₃ – Irrigation at 80 % ET</td>
<td>246.4</td>
<td>13820</td>
<td>11.6</td>
<td>30.0</td>
<td>106.4</td>
<td>5952</td>
</tr>
<tr>
<td>T₄ – Irrigation at 60 % PE</td>
<td>238.2</td>
<td>15336</td>
<td>12.4</td>
<td>32.0</td>
<td>102.6</td>
<td>5573</td>
</tr>
<tr>
<td>T₅ – Irrigation at 60 % ET</td>
<td>226.2</td>
<td>11732</td>
<td>10.2</td>
<td>25.5</td>
<td>99.4</td>
<td>4290</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>19.9</td>
<td>576</td>
<td>0.9</td>
<td>2.6</td>
<td>8.7</td>
<td>119</td>
</tr>
<tr>
<td>SEd</td>
<td>43.4</td>
<td>1256</td>
<td>2.1</td>
<td>5.7</td>
<td>18.9</td>
<td>260</td>
</tr>
</tbody>
</table>

Fig 1: Effect of deficit irrigation practices on Nutrient uptake (kg/ha) of maize hybrid

Conclusion
Deficit irrigation practices significantly influenced the uptake of N, P and K at all the stages of the crop and the increment was progressed as crop age was increased and attained maximum values at harvest. Full watered plants registered higher values followed by alternate deficit irrigation practices and regulated deficit of 80 per cent PE. But, it was on par with each other. Lower values for nutrient uptake was recorded under severely stressed treatment. Thus, it was proved that amount of water can quantify the uptake of nutrients.

References


