Effect of drip irrigation system and fertigation on growth, yield and quality of banana cv. Grand Nain (Musa AAA)

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Abstract
Banana cv. Grand Nain is a newly released cultivar in Sudan with high yield potential and less sensitivity to cool temperature. There is a high demand for exporting this cultivar which will replace the widely grown banana cv. Dwarf Cavendish. Presently, Grand Nain is becoming a popular banana cultivar in Sudan, but the yields are low due to lack of proper water management and fertilization. Crop management (crop water use) and other factors are not well determined under Sudan conditions. This study was conducted to determine the effect of drip irrigation system and fertigation on growth, yield and quality of banana cv. Grand Nain. We studied water quantity and efficiency with fertigation in comparison to farmer practice. The preliminary results indicated that the amount of applied irrigation water with drip irrigation system was lower than that needed under surface irrigation. The banana under drip irrigation system performed better in plant growth and flowered earlier in comparison with surface irrigation.

Key words: Banana, drip irrigation system, efficiency, fertigation, Grand Nain, surface irrigation

Résumé
Background

Bananier, système d’irrigation par gouttes, efficacité, fertilisation, Grand Nain, irrigation de surface

Bananier et plantains sont les quatrièmes cultures alimentaires les plus importantes dans le monde après le riz, le blé et le maïs (Salvador et al., 2007). En Soudan, les superficies cultivées pour le bananier dépassent 12'700 hectares. La plante est bien adaptée au climat chaud et sec avec une productivité supérieure à 50 ton/ha qui a été atteinte sur des sols légers fertiles du bassin du Gash et des rives du fleuve Nil. Généralement, le bananier est irrigué par irrigation de surface qui nécessite plus d’eau et qui rencontre de nombreux problèmes (Walker, 1989). Cela est particulièrement important parce que la quantité d’eau présente dans l’univers est seulement environ 1'520 milliards de kilomètres cubes, 97% est de l’eau de mer et de sel, 2% est de l’eau de l’Arctique et seulement 1% est de l’eau des lacs, des rivières et de l’eau souterraine, qui est de l’eau potable pour l’homme (Shaker, 2004). L’irrigation en gouttelettes (trickle irrigation) est un système prometteur pour économiser l’eau disponible. Il est nécessaire de gérer efficacement l’eau disponible pour maximiser la production de la plante. L’irrigation en gouttelettes peut appliquer de l’eau de manière précise et uniforme à une fréquence d’irrigation élevée comparée à l’irrigation par le ruisseau et le sprinkler irrigation, potentiellement améliorant la productivité, réduisant les pertes d’irrigation sous-surface, fournissant un meilleur contrôle de l’irrigation et des maladies plus efficace des plantes en raison du sol humide seulement et la surface de l’herbe reste sèche (Hanson et May, 2007).

L’application de fertilisants par le système d’irrigation en gouttelettes (fertigation) peut réduire l’utilisation de fertilisants, minimiser le prélèvement d’eau par la pluie et l’irrigation excessive, maximiser l’efficacité de l’utilisation de fertilisants, permettre une flexibilité dans le timing de l’application de fertilisants et réduire le travail nécessaire pour l’application de fertilisants. Les systèmes d’irrigation en gouttelettes sont bien adaptés à la fertigation parce que leur fréquence d’opération réduite et parce que l’application d’eau peut être facilement contrôlée par le manager (Brad Lewis, 2001).
Irrigation is the artificial application of water for the purpose of crop production. Irrigation water is supplied to supplement the water available from rainfall and the contribution to soil moisture from ground water (Michael, 1978). Goenagea and Irizarry (2000) conducted a study on yield performance of banana (Grand Nain) irrigated with fraction of class A pan evaporation. The result showed that irrigation according to increasing pan factors resulted in increase in bunch weight, fruit diameter and length, number of hands per bunch and number of leaves at flowering and at harvest. Some studies were done to compare drip irrigation with surface irrigation. Thadchayini and Thiruchelvam (2005) reported the highest banana yield of 41,000 kg/ha in the drip which was 31% higher than surface irrigation. Hegde and Srinivas (1991) reported an increase in the banana yield under drip irrigation compared with basin irrigation. Hand bunch and finger weight were also higher in drip. Plants were taller (3%) and flowered 15 days earlier under the drip than the basin irrigation. Fertigation can save from 20% to 50% in fertilizers, while improving the yield and quality as compared with the common methods of fertilizer application (Malakouti, 2004). Arscott (1970) reported that application of urea through irrigation system was more efficient than hand broadcasting on soil surface on banana. More yield and significantly higher number of hands per bunch were obtained with fertigation.

The experiment was established at Horticultural Research Center Farm, Agricultural Research Corporation (ARC) Sudan. Six months old planting material propagated by tissue culture was transplanted in the field on 16th of November, 2009 at spacing of 3×3 meter (1111 mother plants/ha) and every plant received 10 kg organic manure. Three months after planting two suckers were left at flower (2222 plants/ha) population. The daily meteorological data were used to compute reference evapotranspiration (ETo). Five different quantities of irrigation were applied at 2 days interval compared with farmers practice (surface irrigation) every 5-7 days. These were 40%, 60%, 80%, 100% and 120% of crop evapotranspiration (ETc) under drip irrigation.

A drip irrigation system was designed and installed on the area of 2145 m² and two emitters per plant were used, the discharge of one emitter was 8 l/h. The recommended fertilizer dose was added by fertigation in drip irrigation treatments and by hand (Traditional method) in surface irrigation treatment. The treatments were replicated 4 times in randomizes complete block
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Research Application

The quantities of water applied to the banana (from 16th-November-09 to 30th-July-10) were 107 m³, 129 m³, 150 m³, 173 m³ and 194 m³ under drip irrigation treatment (40%, 60%, 80%, 100% and 120% of ETc), respectively) compared to 354 m³ for surface irrigation (Fig. 1). The study on the hydraulic characteristic of drip irrigation system gave 7.92 l/h for average emitters discharge, 90.9% field emission uniformity, 86.8%

![Figure 1](Image)

**Figure 1.** The quantities of water (m³) applied by drip and surface irrigation for banana (From 16th-November-09 to 30th-July-10)

**Table 1.** Growth parameters of cv. Grand Nain at 6 month after planting under different treatments.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Pseudostem height (cm)</th>
<th>Pseudostem girth (cm)</th>
<th>Number of leaves per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% of ETc under drip irrigation</td>
<td>101.3</td>
<td>34.1</td>
<td>11.2</td>
</tr>
<tr>
<td>60% of ETc under drip irrigation</td>
<td>86.9</td>
<td>33.9</td>
<td>12.4</td>
</tr>
<tr>
<td>80% of ETc under drip irrigation</td>
<td>112.8</td>
<td>35.9</td>
<td>13.13</td>
</tr>
<tr>
<td>100% of ETc under drip irrigation</td>
<td>114.7</td>
<td>35.8</td>
<td>13.3</td>
</tr>
<tr>
<td>120% of ETc under drip irrigation</td>
<td>120</td>
<td>34.6</td>
<td>13.98</td>
</tr>
<tr>
<td>Surface irrigation</td>
<td>110.8</td>
<td>34.8</td>
<td>13.15</td>
</tr>
<tr>
<td>F-prob</td>
<td>0.115</td>
<td>0.93</td>
<td>0.066</td>
</tr>
<tr>
<td>CV%</td>
<td>15.1</td>
<td>8.9</td>
<td>9.1</td>
</tr>
</tbody>
</table>
absolute emission uniformity and 91.9% design emission uniformity. Better growth parameters were found in 120% and 100% of ETc under drip irrigation system compared with surface irrigation (Table 1).

Time to flowering (shooting) started earlier in 100% followed by 120%, 60%, 40% and 80% of ETc, respectively.

Acknowledgement

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