Effect of fertigation on nitrogen & water use efficiency, chlorophyll fluorescence and normalized difference vegetation index of chilli crop under drip irrigation

Rahul Makkar, RK Jhorar, Sanjay Kumar and Ashwani

Abstract

This study was carried out during 11 August, 2017 to 10 December, 2017. The area is characterized as semi-arid. The average annual rainfall of the district is 450 mm which is unevenly distributed over the area. The district area forms a part of Indo-Gangetic plain. The area as a whole is almost flat alluvial plain dotted with sand hummocks and sand dunes. Fertigation was applied with good quality water under drip irrigation. Similarly, fertilizer was applied under surface irrigation. Under drip, three nitrogen fertigation levels (i.e. 75%, 100% and 125% of RDN) were imposed. The recommended dose of NPK for chilli crop is 62.30 & 30 kg/ha respectively. To compare the results of drip irrigation one treatment of control was composed with surface irrigation having 100% RDN. Water use efficiency (WUE), nitrogen use efficiency (NUE), chlorophyll fluorescence and normalized difference vegetation index was computed for each treatment. Chilli yield obtained under weekly fertigation with RDN was 20.67% higher under drip irrigation (11.56 t/ha) as compared to weekly fertilizer application of RDN under surface irrigation (9.58 t/ha). Chilli yield obtained under fortnightly fertigation with RDN was 38.55% higher under drip irrigation (10.53 t/ha) as compared to fortnightly fertilizer application of RDN under surface irrigation (7.60 t/ha).

Keywords: Fertigation, nitrogen, chlorophyll fluorescence, drip irrigation

1. Introduction

Drip irrigation, due to its capability to apply small and frequent amounts of fertilizers dissolved in irrigation water (fertigation), also promises to apply fertilizers with high fertilizer use efficiency. In fertigation nutrient use efficiency could be as high as 90% compared to 40-60% in conventional method mainly due to decreased leaching of nutrients under drip irrigation (Solaimalai et al., 2005) [6]. When nutrients are applied as broadcast or band placement, due to various losses the fertilizer use efficiency could not be improved. But fertigation pave the way to alter the application rates and frequency to suit the crop requirement at different growth stages, which in-turn increases the fertilizer use efficiency. Fertigation provides the essential nutrients directly to the active root zone, thus minimizing the loss of expensive nutrients which ultimately helps in improving the productivity and quality of farm produce. An increase in the use efficiency of nitrogen, phosphorus and potassium has been reported to the extent of 95, 45 and 80 percent, respectively (Satisha, 1997) [5]. Crop growth and yields under drip irrigation can be lower than those achieved under conventional irrigation method if fertilizer placement is not modified to meet the needs of drip irrigated crops (Miller et al., 1976) [4]. This calls for identification of suitable fertigation strategy to supply the desired nutrients in quantity. Fertigation increases effective use of water and fertilizers, gives higher yield, improves quality of production and protects environment. Inappropriate fertigation may decrease the expected yield benefits of drip irrigated crops. In India, chilli is grown over an area of 0.654 million hectare with production of 1.146 million tonnes, with productivity of 1551 kg/ha. The most important chilli states in India are Andhra Pradesh (51%), Madhya Pradesh (11%), Karnataka (9%), Orissa (4%), Maharashtra (4%), Rajasthan (3%) and Tamil Nadu (3%) (Jagtap et al., 2012) [9]. It is a crop of tropical and sub-tropical regions and requires a warm humid climate. The drip irrigation offer opportunity to increase crop production by efficient resources management such as supplying water and nutrients as and when required.

2. Materials and Methods

The experimental site is located at 29°09’0.97”N latitude and 75°42’20.12”E longitude. Micro plots are constructed of brick lined isolated chamber with inside dimension 2m x 2m
(length x width) and open from bottom. To avoid any damage from the animals, it was fully covered with wire mesh. This study was carried out during 11 August, 2017 to 10 December, 2017. The area is characterized as semiarid. The average annual rainfall of the district is 450mm which is unevenly distributed over the area. The district area forms a part of Indo-Gangetic plain. The area as a whole is almost flat alluvial plain dotted with sand hummocks and sand dunes. Fertigation was applied with good quality water under drip irrigation. Similarly, fertilizer was applied under surface irrigation. Under drip, three nitrogen fertigation levels (i.e. 75%, 100% and 125% of RDN) were imposed. The recommended dose of N P K for chilli crop is 62, 30 & 30 kg/ha respect [1]. To compare the results of drip irrigation one treatment of control was composed with surface irrigation having 100% RDN. To maintain the uniform distribution of water through drip irrigation, the drippers discharge was checked randomly. The average discharge of drippers was 1.81 l/h.

2.1 Treatment details

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Treatment</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Weekly fertigation with 75% of RDN</td>
<td>F1N1</td>
</tr>
<tr>
<td>2</td>
<td>Weekly fertigation with 100% of RDN</td>
<td>F1N2</td>
</tr>
<tr>
<td>3</td>
<td>Weekly fertigation with 125% of RDN</td>
<td>F1N3</td>
</tr>
<tr>
<td>4</td>
<td>Fortnightly fertigation with 75% of RDN</td>
<td>F2N1</td>
</tr>
<tr>
<td>5</td>
<td>Fortnightly fertigation with 100% of RDN</td>
<td>F2N2</td>
</tr>
<tr>
<td>6</td>
<td>Fortnightly fertigation with 125% of RDN</td>
<td>F2N3</td>
</tr>
<tr>
<td>7</td>
<td>Surface irrigation weekly fertilizer application with 100% RDN</td>
<td>SF1</td>
</tr>
<tr>
<td>8</td>
<td>Surface irrigation fortnightly fertilizer application with 100% RDN</td>
<td>SF2</td>
</tr>
</tbody>
</table>

Note: RDN-Recommended dose of Nitrogen

2.2 Water use efficiency: Water use efficiency (WUE) represents the relation between yield and irrigation water. WUE of different treatment was calculated in term of fruit yield per hectare to the amount of water used per hectare.

\[
\text{WUE (kg/m}^3\text{)} = \frac{\text{Chilli yield (kg/ha)}}{\text{Amount of water applied (m}^3\text{/ha)}}
\]

2.3 Nitrogen use efficiency: Nitrogen use efficiency (NUE) represents the relation between yield and amount of nitrogen applied. NUE of different treatment was calculated in term of fruit yield per hectare to the amount of nitrogen applied per hectare.

\[
\text{NUE (kg/kg)} = \frac{\text{Chilli yield (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}
\]

2.4 Chlorophyll fluorescence (photochemical efficiency) analysis: Average chlorophyll fluorescence (CFL) values are presented in Table 4.7 from 40 to 115 DAT. It was observed that F1N3 has the highest CFL (F1/F0) ranging from 0.678 to 0.817 (40 to 115 DAT) whereas lowest CFL was observed in SF2, ranging from 0.504 to 0.623 (40 to 115 DAT).

2.5 NDVI Analysis: Average NDVI is presented in Table 4.8 from 40 to 115 DAT of the crop. NDVI pattern for all the treatment was same as for CFL. It was observed that F1N3 has the highest NDVI ranging from 0.71 to 0.78 (40 to 115 DAT) whereas lowest was observed under SF2, ranging from 0.51 to 0.57 (40 to 115 DAT).

3. Results and Discussion

3.1 Water use efficiency

In surface irrigation, relatively higher amount of water (1634 l/plot) was used as compared to drip irrigation (880.3 l/plot). Accordingly the WUE was lower in SF1 and SF2 treatments. Same amount of water (880.3 l/plot) was used in all treatments under drip system. Therefore in drip irrigation WUE in a treatment is directly proportional to the yield obtained under that treatment. WUE under F1N2 and F1N3 was significantly higher than F1N1 treatment. In general WUE was either significantly higher or at par with increasing levels of N-fertigation considered in the study with respect to fertigation frequencies. WUE was higher for weekly N-fertigation as compared to fortnightly N-fertigation. The highest WUE (5.56 kg/m³) was obtained under weekly fertigation with 125% RDN (F1N3), followed by 100% RDN (F1N2) having 5.25 kg/m³. These results were supported by Kumar et al. (2017) [3] in tomato. On comparing the frequencies of different fertigation, weekly fertigation treatments obtained 9.9%, 8.9% and 12.23% higher NUE respectively in F1N2, F1N3 & F1N1 than fortnightly fertigation with respective fertigation level. Among all the treatments F1N3 has obtained the highest water use efficiency (5.56 kg/m³) which was also significantly higher than the equivalent
treatment (F₂N₃) under fortnightly frequency of N-application. Therefore it may be stated that for chilli crop among all the treatments imposed during this study, the treatment having application of 125% RDN at weekly frequency gave best results considering both yield and WUE.

3.2 Nitrogen use efficiency

Nitrogen use efficiency (NUE) is directly proportional to the yield and inversely proportional to nitrogen applied as fertilizer. Significantly higher NUE was obtained for respective doses of N application under weekly fertigation frequency as compared to fortnightly frequency of N-fertigation. NUE under F₁N₁ and F₁N₂ treatments has no significant difference but on comparing with F₁N₃ its value is significantly higher under F₁N₁ and F₁N₂ treatments. Similar results were also obtained in fortnightly fertigation treatments. For a given fertigation frequency, the NUE under all the drip irrigation treatments, as compared to surface irrigation treatments, was higher for all the levels of fertigation.

3.3 Chlorophyll fluorescence (photochemical efficiency) analysis: Results for chlorophyll fluorescence (CFL) was presented in Table 2. The line diagrams of CFL in relation to observation period were plotted in Figure 2. From these figures, it was observed that the CFL of all the treatments increased in the first four observations (from 40 to 85 DAT) and decreased in last two observations (100 to 115 DAT). Crop yield was also increased with the increase in these chlorophyll activities and with the decrease in these activities, crop yield decreased. In weekly fertigation treatment at 85 DAT, 18.3 and 22% higher CFL was recorded in F₁N₂ and F₁N₃, respectively in comparison to F₁N₁ treatment. Similarly, in fortnightly fertigation treatment, 9.2 and 13% higher CFL was recorded in F₂N₂ and F₂N₃, respectively in comparison to F₂N₁ treatment. On comparing the frequencies of different fertigation treatment, weekly fertigation treatments obtained 2.8, 11.4 and 11% higher CFL than fortnightly fertigation treatment.

4. Conclusion

Water application with average drip discharge of 1.81 l/h in the experimental soil (loamy sand having basic infiltration rate of 2.96cm/h) resulted into predominantly downward movement of water as compared to lateral movement. Hence, it indicated that drippers with high discharge be used under such situations to achieve desired lateral movement of soil moisture from the point of application. Chilli yield obtained under weekly fertigation with RDN was 20.67% higher under drip irrigation (11.56 t/ha) as compared to weekly fertilizer application of RDN under surface irrigation (9.58 t/ha). Chilli yield obtained under fortnightly fertigation with RDN was 38.55% higher under drip irrigation (10.53 t/ha) as compared to fortnightly fertilizer application of RDN under surface irrigation (7.60 t/ha).

5. References