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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 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 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) [2]. 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 $29^0$09'0.97"N latitude and $75^0$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 respectively (Anonymous, 2013) [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.

Fig 1: Experimental View

2.1 Treatment details

Table 1: Different treatments of nitrogen fertigation of chilli

S. No.	Treatment	Abbreviation
1	Weekly fertigation with 75% of RDN	F_1N_1
2	Weekly fertigation with 100% of RDN	F_1N_2
3	Weekly fertigation with 125% of RDN	F_1N_3
4	Fortnightly fertigation with 75% of RDN	F_2N_1
5	Fortnightly fertigation with 100% of RDN	F_2N_2
6	Fortnightly fertigation with 125% of RDN	F_2N_3
7	Surface irrigation weekly fertilizer application with 100% RDN	SF_1
8	Surface irrigation fortnightly fertilizer application with 100% RDN	SF_2

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 F_1N_3 has the highest CFL (F_v/F_m) ranging from 0.678 to 0.817 (40 to 115 DAT) whereas lowest CFL was observed in SF_2, ranging from 0.504 to 0.623 (40 to 115 DAT).

Table 2: Average CFL of chilli crop different treatments at 15 days interval

Treatments	40 DAT	55 DAT	70 DAT	85 DAT	100 DAT	115 DAT
F_1N_1	0.577	0.602	0.652	0.670	0.622	0.557
F_1N_2	0.672	0.711	0.775	0.793	0.747	0.665
F_1N_3	0.691	0.745	0.799	0.817	0.784	0.678
F_2N_1	0.573	0.582	0.623	0.652	0.573	0.508
F_2N_2	0.623	0.639	0.695	0.712	0.667	0.586
F_2N_3	0.644	0.661	0.718	0.736	0.687	0.605
SF_1	0.585	0.620	0.663	0.678	0.634	0.558
SF_2	0.531	0.566	0.609	0.623	0.580	0.504

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 F_1N_3 has the highest NDVI ranging from 0.71 to 0.78 (40 to 115 DAT) whereas lowest was observed under SF_2, ranging from 0.51 to 0.57 (40 to 115 DAT).

Table 3: Average NDVI of different treatments at 15 days interval

Treatments	40 DAT	55 DAT	70 DAT	85 DAT	100 DAT	115 DAT
F_1N_1	0.56	0.58	0.59	0.62	0.59	0.55
F_1N_2	0.68	0.69	0.71	0.75	0.74	0.73
F_1N_3	0.71	0.72	0.73	0.78	0.77	0.76
F_2N_1	0.52	0.53	0.54	0.58	0.57	0.55
F_2N_2	0.62	0.64	0.65	0.70	0.68	0.67
F_2N_3	0.64	0.65	0.67	0.71	0.69	0.67
SF_1	0.59	0.61	0.63	0.64	0.61	0.60
SF_2	0.51	0.52	0.53	0.57	0.55	0.53

3. Results and Discussion

3.1 Water use efficiency

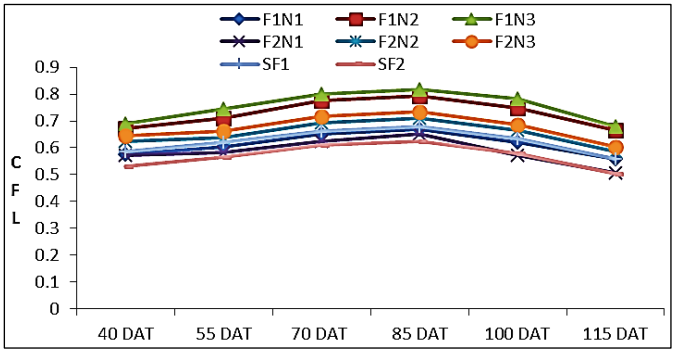
In surface irrigation, relatively higher amount of water (1634 l/plot) was used as compared to drip irrigation (880.3 l/plot). Accordingly the WUE was lower in SF_1 and SF_2 treatments. Same amount of water (880.3 l/plot) was used in all treatments under drip system. Therefore in drip irrigation WUE in a treatment is directly proportional to the yield obtained under that treatment. WUE under F_1N_2 and F_1N_3 was significantly higher than F_1N_1 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/m^3) was obtained under weekly fertigation with 125% RDN (F_1N_3), followed by 100% RDN (F_1N_2) having 5.25 kg/m^3. 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 F_1N_1, F_1N_2 & F_1N_3 than fortnightly fertigation with respective fertigation level. Among all the treatments F_1N_3 has obtained the highest water use efficiency (5.56 kg/m^3) which was also significantly higher than the equivalent

treatment (F_2N_3) 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 F_1N_1 and F_1N_2 treatments has no significant difference but on comparing with F_1N_3 its value is significantly higher under $F_1N_1$and F_1N_2 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.

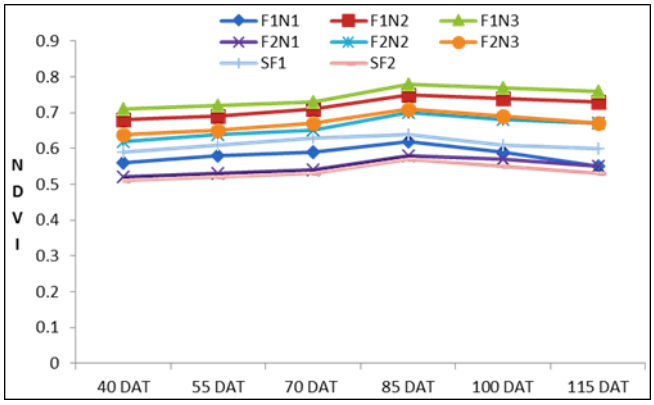
3.3 Chlorophyll fluorescence (photochemical efficiency) analysis: Results for chlorophyll fluorescence (CFL) was presented in Table 2. The line diagrams of CFL in relation to observation period were plotted in Figure 2. From these figures, it was observed that the CFL of all the treatments increased 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 F_1N_2 and F_1N_3, respectively in comparison to F_1N_1 treatment. Similarly, in fortnightly fertigation treatment, 9.2 and 13% higher CFL was recorded in F_2N_2 and F_2N_3, respectively in comparison to F_2N_1 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.



Days after transplanting

Fig 2: Line diagram of CFL at different interval of all treatments

3.4 NDVI (Normalized difference vegetation index) analysis: Results for Normalized difference vegetation index (NDVI) was presented in Table 3. The line diagrams of NDVI in relation to observation period were plotted in Figure 3. From these figures, it was observed that the NDVI 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 vegetation index and with the decrease in these activities, crop yield decreased. In weekly fertigation treatment at 85 DAT, 21 and 26% higher NDVI was recorded in F_1N_2 and F_1N_3, respectively in comparison to F_1N_1 treatment. Similarly, in fortnightly fertigation treatment, 20.6 and 22.4% higher NDVI was recorded in F_2N_2 and F_2N_3, respectively in comparison to F_2N_1 treatment. On comparing the frequencies of different fertigation treatment, weekly fertigation treatments obtained 6.4, 6.7 and 9% higher NDVI than fortnightly fertigation treatment.



Days after transplanting

Fig 3: Line diagram of NDVI at different interval of all treatments

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

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