



## **Performance of *Rabi* Sunflower to Different Levels of Drip Irrigation Regimes and Fertigation**

**A. Sairam<sup>a\*#</sup>, K. Avil Kumar<sup>a≡</sup>, G. Suresh<sup>b<sup>o</sup></sup> and K. Chaitanya<sup>a†</sup>**

<sup>a</sup> PJTS Agricultural University, Rajendranagar, Hyderabad 500030, Telangana, India.

<sup>b</sup> ICAR-IIOR, Rajendranagar, Hyderabad 500030, Telangana, India.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Sunflower (*Helianthus annuus* L.) is an important oilseed crop in India popularly known as "Surakanthi flower". It belongs to the family Asteraceae. The global challenge for the coming decades is to increase the food production with utilization of less water. It can be partially achieved by increasing crop water use efficiency (WUE). Improving the water and nutrient use efficiency has become imperative in present day's Agriculture. A field trial was conducted at Water Technology Center, College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJ TSAU), Rajendranagar, during *rabi* season (2018-19) to study the effect of different levels of drip irrigation regimes and fertigation on *rabi* sunflower. The experiment was carried out under split plot design with three main plot treatments (Irrigation regimes) and four sub-plot treatments (Fertigation levels) and replicated thrice. In irrigation levels sunflower performed better under 1.2 and 1.0 Epan in growth parameters followed by 0.8 Epan. The growth parameters, viz., plant height (214.4 & 214.6 cm), Number of leaves per plant (24.7 & 24.6), LAI (5.63 & 5.27), dry matter accumulation (6041 kg ha<sup>-1</sup> & 5683 kg ha<sup>-1</sup>), Root depth (17.2 cm & 17.4 cm) and Root volume (91.5 cm<sup>3</sup> & 101.0 cm<sup>3</sup>) were found significantly higher at 1.2 Epan and 1.0 Epan. Among fertigation levels, fertigation with 120% RD N & K<sub>2</sub>O reported higher plant height (216.8 cm), Number of leaves per plant (25.5), LAI (5.96), dry matter accumulation (5950 kg ha<sup>-1</sup>), Root depth (18.6 cm)

# Research Scholar;

≡ Director WTC;

<sup>o</sup> Principal Scientist;

† Scientist;

\*Corresponding author: E-mail: [sairamnetha524@gmail.com](mailto:sairamnetha524@gmail.com);

and Root volume ( $103.2 \text{ cm}^3$ ) followed by 80% RD N &  $\text{K}_2\text{O}$  and 60% RD N &  $\text{K}_2\text{O}$ . The economic yield reported higher at 1.0 Epan ( $2082 \text{ kg ha}^{-1}$ ) and 100% RD N &  $\text{K}_2\text{O}$  ( $2162 \text{ kg ha}^{-1}$ ) in main and sub plot treatments than other treatments. The benefit-cost ratio was reported highest for Drip irrigation scheduled at 1.0 Epan (2.52) and fertigation with 100% RD N &  $\text{K}_2\text{O}$  (2.59) among the Irrigation and fertigation levels and concluded that drip irrigation scheduled at 1.0 Epan with 100% RD N &  $\text{K}_2\text{O}$  showed the best results.

**Keywords:** Drip; fertigation; irrigation; sunflower and B:C ratio.

## 1. INTRODUCTION

In India, sunflower was introduced as oil seed crop in 1965 but commercial cultivation was started in 1972 with the introduction of Russian cultivars. It is an important oilseed crop contributes 1.4 per cent of the total oilseed production from nine major oil seed crops. It was cultivated over an area of about 2.8 lakh hectares with a production of 2.2 lakh tones and productivity of  $643 \text{ kg ha}^{-1}$  [1]. The projected population of India was expected to be around 1.39 billion by 2025 Anno Domini AD and the required oil seeds production and oil requirement will be around 102.3 million tonnes and 34.10 million tonnes by 2030 AD [2]. Sunflower holds great promise as oilseed crop because of its versatility, photo insensitiveness, short duration, day neutral crop (cultivated in *kharif*, *rabi* and *summer* seasons), and best for contingent crop, high degree of adaptability to different soils and climatic conditions, easy for cultivation, low seed rate, high seed multiplication ratio (1:80), higher market price, drought tolerant, good scope of diversified cropping pattern, high quality of oil (poly unsaturated fatty acids) content and deep root system [3]. The oil demand was increasing day to day so we need to increase area and production of sunflower by using optimum irrigation and fertigation methods. Drip irrigation is a very efficient method, which reduces water requirement of crop [4]. It minimizes conventional losses of water by deep percolation, evaporation and run off. Fertigation of nutrients significantly increased saving of fertilizer nutrients up to 40 per cent without affecting the yield of crops compared to the conventional method of nutrient application [5]. Hence a study is proposed as the information on fertigation to increase the yield potential of sunflower was under taken in order to assess the effect of drip irrigation regimes and fertigation levels on growth, yield and economics of sunflower.

## 2. MATERIALS AND METHODS

The field experiment was conducted during *rabi* 2019-2020 at Water Technology Center, College

farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad sandy clay loam soil which was alkaline in reaction and non-saline [6], low in available nitrogen, high in available phosphorous and available potassium, medium in organic carbon content, having total available soil moisture 60.91 mm in 45 cm depth of soil. Irrigation water was bit alkaline (7.22 pH) and was classified as C3 class suggesting that it is suitable for irrigation by following good management practices. The experiment was laid out in a split plot design consisting of three main irrigation regimes *viz.*, drip irrigation scheduled at 0.8, 1.0 and 1.2 Epan and four fertigation levels of 60% recommended dose (RD) N &  $\text{K}_2\text{O}$ , 80% RD N &  $\text{K}_2\text{O}$ , 100% RD N &  $\text{K}_2\text{O}$  and 120% RD N &  $\text{K}_2\text{O}$  and replicated thrice. The irrigation was scheduled based on pan evaporation replenishment in  $I_1$  to  $I_3$  treatments. The irrigation water was applied on the basis of pan evaporation (PE) data (USWB open pan evaporimeter) obtained from the Agro Climate Research Centre, ARI, Rajendranagar, Hyderabad. In drip irrigation system, irrigation water was applied at alternate day. During rainy days the volume of water applied to each treatment was adjusted for the effective rainfall received and it was only 23.2 mm in entire crop growth period. Daily crop evapotranspiration was estimated with pan evaporation from agro meteorological observatory, accordingly application rate and operation time of drip was calculated. The laterals of 16 mm diameter were laid at 0.8 m apart with emitter spacing of 0.4 m distance between two inline emitters. The emitter discharge was 2.0 LPH (litres per hour). The RD of nutrients were 75:90:30 kg NPK  $\text{ha}^{-1}$  and entire dose of  $\text{P}_2\text{O}_5$  was applied as basal, N and  $\text{K}_2\text{O}$  was applied as fertigation in 18 splits in the form of urea and sulphate of potash (SoP) based on crop requirement at each stage with 4 days interval from 10 days after sowing onwards. The data of Epan was collected from agro meteorological observatory away from 500 m at Agricultural Research Institute, Rajendranagar and accordingly application rate and drip system

operation time was calculated. The crop was irrigated once in 2 days. Need based plant protection measures were taken up and kept weeds low to avoid crop weed competition by weeding at 30 days after sowing. When crop reach harvested maturity stage net plot yield was taken and computed to kg per hectare. The data collected related to growth and yield parameters was statistically analyzed as suggested by Gomez and Gomez [7].

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth Parameters

Data on different levels of drip irrigation regimes and fertigation on growth parameters are prescribed in Table.1. Among irrigation levels significantly higher plant height of *rabi* sunflower was observed with drip scheduled at 1.0 Epan (214.6 cm) compared with drip irrigation scheduled at 0.8 Epan (199.7 cm), and was on par with 1.2 Epan (214.4 cm). In fertigation levels, 100% RD of N & K<sub>2</sub>O recorded significantly higher plant height (217.5 cm) than 80% RD of N & K<sub>2</sub>O (207.7 cm) and 60% RD of N & K<sub>2</sub>O (196.1 cm) and was on par with 120% RD of N & K<sub>2</sub>O (216.8 cm). The increased plant height with increase in drip irrigation level could be traced to favorable soil water maintained in the effective crop root zone depth with higher frequency of irrigation. An optimal soil and plant water balance under drip irrigation scheduled at 1.2 Epan and 1.0 Epan treatments might have stimulated increased activity of meristematic cells and cell elongation of internodes resulting in higher growth rate of stem in turn promoting higher plant height of sunflower [8,9].

Higher number of leaves plant<sup>-1</sup> recorded with drip irrigation scheduled at 1.2 Epan (24.7) and it was significantly different from leaf number realized with 0.8 Epan (20.7) and was on par with 1.0 Epan (24.6). Data presented in Table.1 showed that the number of leaves plant<sup>-1</sup> with fertigation levels of 120%RD N & K<sub>2</sub>O (25.5) and 100%RD N & K<sub>2</sub>O recorded were on par with each other and were significantly higher than 80%RD N & K<sub>2</sub>O (22.5) and 60%RD N & K<sub>2</sub>O (19.8). The number of leaves plant<sup>-1</sup> were increased with increase in fertigation dose due to better availability and uptake of nutrients in tune with the growth rate resulting in better growth and development interms of plant height resulting in more number of leaves.

Significantly greater LAI was achieved with irrigation scheduled at 1.2 Epan (5.63) compared to 0.8 Epan (4.37) and was on par with 1.0 Epan (5.27). Drip irrigation scheduled at 0.8 Epan observed significantly lower LAI than other two irrigation levels. Improved LAI under drip irrigation scheduled at 1.2 Epan and 1.0% Epan treatments could be attributed to maintenance of higher soil water potential contributing favourable plant water balance as compared to the crop in deficit irrigation treatment (0.8 Epan). Among varied fertigation levels, 120%RD N & K<sub>2</sub>O recorded significantly higher LAI (5.96) than 80%RD N & K<sub>2</sub>O (4.81) and 60%RD N & K<sub>2</sub>O (4.20) and was not significantly different with 100%RD N & K<sub>2</sub>O (5.38). The LAI increased with enhancement in fertigation of RD N & K<sub>2</sub>O level from 60% to 120% and this was due to higher availability of NPK.

Drip irrigation scheduled at 1.2 Epan produced significantly higher dry matter (6041 kg ha<sup>-1</sup>) compared with 1.0 Epan (5683 kg ha<sup>-1</sup>) and 0.8 Epan (4864 kg ha<sup>-1</sup>). However, significantly lower dry matter was recorded with drip irrigation scheduled at 0.8 Epan over 1.0 Epan and 1.2 Epan. Fertigation with 120%RD N & K<sub>2</sub>O (5950 kg ha<sup>-1</sup>) recorded significantly superior dry matter than 80%RD N & K<sub>2</sub>O (5422 kg ha<sup>-1</sup>) and 60%RD N & K<sub>2</sub>O (4918 kg ha<sup>-1</sup>) and was not significant with 100%RD N & K<sub>2</sub>O (5829 kg ha<sup>-1</sup>). Application of water and nutrients through drip system which enabled continuous availability of optimum soil moisture and nutrients in the root zone facilitating effective absorption of water and nutrients by plants at higher irrigation levels which lead to increases nutrient uptake results higher plant height, number of leaves, and LAI increases the photo synthesis, ultimately it increased dry matter.

Significantly higher root depth and root volume of *rabi* sunflower were recorded when drip irrigation was scheduled at 1.2 Epan (17.4 cm & 101.0 cm<sup>3</sup>) over 0.8 Epan (14.8 cm & 72.6 cm<sup>3</sup>) and was on par with drip irrigation at 1.0 Epan (17.2 cm & 91.5 cm<sup>3</sup>). Drip fertigation of 120%RD N & K<sub>2</sub>O (18.6 cm & 103.2 cm<sup>3</sup>) and 100%RD N & K<sub>2</sub>O (17.7 cm & 98.1 cm<sup>3</sup>) were on par each other and recorded significantly superior root depth and volume at harvest compared with 80%RD N & K<sub>2</sub>O (16.0 cm & 85.2 cm<sup>3</sup>) and 60%RD N & K<sub>2</sub>O (13.7 cm & 67.0 cm<sup>3</sup>).

Table 1. Growth parameters of *rabi* sunflower as influenced by different levels of drip irrigation regimes and fertigation

Treatments	Plant height (cm)	No. of leaves	LAI	Dry matter (kg ha <sup>-1</sup> )	Root depth (cm)	Root volume (cm <sup>3</sup> )
<b>Main plot – (Irrigation regimes) :</b>						
I <sub>1</sub> : Drip irrigation at 0.8 Epan	199.7	20.7	4.37	4864	14.8	72.6
I <sub>2</sub> : Drip irrigation at 1.0 Epan	214.6	24.6	5.27	5683	17.2	91.5
I <sub>3</sub> : Drip irrigation at 1.2 Epan	214.4	24.7	5.63	6041	17.4	101.0
SEm ±	2.2	0.3	0.12	54	0.2	2.5
C.D (P=0.05)	8.8	1.2	0.49	212	1.0	9.8
<b>Sub plot – (Fertigation levels) :</b>						
F <sub>1</sub> – 60 % RD N & K <sub>2</sub> O	196.1	19.8	4.20	4918	13.7	67.0
F <sub>2</sub> – 80 % RD N & K <sub>2</sub> O	207.7	22.5	4.81	5422	16.0	85.2
F <sub>3</sub> – 100 % RD N & K <sub>2</sub> O	217.5	25.4	5.38	5829	17.7	98.1
F <sub>4</sub> – 120 % RD N & K <sub>2</sub> O	216.8	25.5	5.96	5950	18.6	103.2
SEm ±	3.1	0.5	0.23	94	0.5	2.1
C.D (P=0.05)	9.2	1.6	0.70	280	1.4	6.2
<b>Interaction :</b>						
<b>Fertigation levels at same level of irrigation regimes :</b>						
SEm ±	5.4	0.9	0.41	164	0.8	3.7
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
<b>Irrigation regimes at same or different levels of fertigation :</b>						
SEm ±	5.2	0.9	0.37	151	0.7	4.0
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

**Table 2. Yield parameters, yield and B:C ratio of *rabi* sunflower as influenced by different levels of drip irrigation regimes and fertigation**

Treatments	Head diameter (cm)	No. of seeds head <sup>-1</sup>	Threshing (%)	Economic yield (kg ha <sup>-1</sup> )	Oil yield (kg ha <sup>-1</sup> )	B:C ratio
<b>Main plot – (Irrigation regimes) :</b>						
I <sub>1</sub> : Drip irrigation at 0.8 Epan	14.1	578.5	29.4	1781	707	2.20
I <sub>2</sub> : Drip irrigation at 1.0 Epan	16.0	687.6	40.4	2082	814	2.52
I <sub>3</sub> : Drip irrigation at 1.2 Epan	15.6	677.4	37.8	2028	794	2.38
SEm ±	0.3	17.8	0.7	51	20	0.06
C.D (P=0.05)	1.4	70.0	3.0	200	78	0.23
<b>Sub plot – (Fertigation levels) :</b>						
F <sub>1</sub> – 60 % RD N & K <sub>2</sub> O	13.7	540.1	29.0	1688	671	2.08
F <sub>2</sub> – 80 % RD N & K <sub>2</sub> O	14.9	586.5	34.5	1872	739	2.27
F <sub>3</sub> – 100 % RD N & K <sub>2</sub> O	16.2	737.2	40.3	2162	844	2.59
F <sub>4</sub> – 120 % RD N & K <sub>2</sub> O	16.0	727.6	39.7	2133	834	2.52
SEm ±	0.3	25.7	1.0	73	32	0.09
C.D (P=0.05)	1.1	76.5	3.0	219	95	0.26
<b>Interaction :</b>						
<b>Fertigation levels at same level of irrigation regimes :</b>						
SEm ±	0.6	44.6	1.7	127	55	0.15
C.D (P=0.05)	NS	NS	NS	NS	NS	NS
<b>Irrigation regimes at same or different levels of fertigation :</b>						
SEm ±	0.6	42.5	1.7	121	52	0.15
C.D (P=0.05)	NS	NS	NS	NS	NS	NS

### 3.2 Yield Parameters

Maximum head diameter of sunflower was recorded in drip irrigation scheduled at 1.0 Epan (16.0 cm) compared with 0.8 Epan (14.1 cm) and was on par with drip irrigation scheduled at 1.2 Epan (15.6 cm). Irrigation at 0.8 Epan produced significantly lower head diameter than rest of the irrigation levels. Fertigation with 100% RD N & K<sub>2</sub>O recorded significantly higher head diameter of *rabi* sunflower (16.2 cm) than 80%RD N & K<sub>2</sub>O (14.9 cm) and 60%RD N & K<sub>2</sub>O (13.7 cm) and was not significantly differ with 120% RD N & K<sub>2</sub>O (16.0 cm). Fertigation with 120% RD N & K<sub>2</sub>O was next to 100% RD N & K<sub>2</sub>O and was on par with 80% RD N & K<sub>2</sub>O. This might be due to higher availability of nutrients in 100% and 120% RD N & K<sub>2</sub>O compared to other treatment, there by higher plant height, number of leaves and LAI and more head diameter. These results are in supporting with the findings of Himaja, [10] and Preethika, [11].

Number of seeds head<sup>-1</sup> presented in Table. 2 indicated that significantly maximum number of seeds were observed with irrigation scheduled at 1.0 Epan (687.6) than 0.8 Epan (578.5) and was on par with 1.2 Epan (677.4). Among the fertigation levels, 100% RD N & K<sub>2</sub>O (737.2) and 120% RD N & K<sub>2</sub>O (727.6) recorded significantly greater number of seeds head<sup>-1</sup> than 80% RD N & K<sub>2</sub>O (586.5) and 60% RD N & K<sub>2</sub>O (540.1).

The shelling per cent was not significantly influenced by irrigation regimes and fertigation of RD N & K<sub>2</sub>O levels and by their interactions. However higher shelling per cent was recorded with drip irrigation scheduled at 1.0 Epan (70.2%) and fertigation with 60% RD N & K<sub>2</sub>O (73.7%) than rest of the treatments.

Significantly higher seed yield of *rabi* sunflower was recorded with drip irrigation scheduled at 1.0 Epan (2082 kg ha<sup>-1</sup>) than irrigation at 0.8 Epan (1781 kg ha<sup>-1</sup>) and was on par with 1.2 Epan (2028 kg ha<sup>-1</sup>). Among fertigation levels, significantly higher seed yield (2162 kg ha<sup>-1</sup>) was observed with fertigation of 100%RD N & K<sub>2</sub>O over fertigation of 80%RD N & K<sub>2</sub>O (1872 kg ha<sup>-1</sup>) and 60% RD N & K<sub>2</sub>O (1688 kg ha<sup>-1</sup>) and was on par with fertigation of 120%RD N & K<sub>2</sub>O (2133 kg ha<sup>-1</sup>). The results were in similar trend with the results reported by Akanksha, [12] and Kumar et al. [13].

The oil yield followed the trend as that of seed yield presented in Table 2 indicated that

significantly higher oil yield was recorded with drip irrigation scheduled at 1.0 Epan (814 kg ha<sup>-1</sup>) than 0.8 Epan (707 kg ha<sup>-1</sup>) and was on par with irrigation at 1.2 Epan (794 kg ha<sup>-1</sup>). Fertigation with 100% RD N & K<sub>2</sub>O recorded significantly higher oil yield (844 kg ha<sup>-1</sup>) than 80% RD N & K<sub>2</sub>O (739 kg ha<sup>-1</sup>) and 60% RD N & K<sub>2</sub>O (671 kg ha<sup>-1</sup>) and was statistically on par with fertigation with 120% RD N & K<sub>2</sub>O (834 kg ha<sup>-1</sup>).

Among varied fertigation levels significantly higher (2.59) and lower (2.08) B:C ratios were found with fertigation of 100%RD N & K<sub>2</sub>O and 60%RD N & K<sub>2</sub>O treatments which were on par with 120% RD N & K<sub>2</sub>O (2.52) and 80% RD N & K<sub>2</sub>O (2.27), respectively. B:C ratio with fertigation of 60%RD N & K<sub>2</sub>O was significantly lower than the fertigation of 100% and 120% RD N & K<sub>2</sub>O. This may be due to relative increase in fertility level did not increase the yield proportional to increased cost of inputs. Results obtained by Preethika et al. [11] and Tahir et al. [14] corroborate with the findings of present investigation B:C ratio.

### 4. CONCLUSION

Based on above results its can be concluded that drip irrigation scheduled at 1.0 Epan and 1.2 Epan reported higher values in growth and yield parameters of *rabi* sunflower. Among the different fertigation levels, highest yield was reported with 100% RD of N & K<sub>2</sub>O. Soil moisture deficit and lack of nutrients in soil are the most important constraint for crop production during *rabi* season. Therefore, inclusion of efficient water distribution system with irrigation scheduling at 1.0 Epan and fertigation with 100% R D of N & K<sub>2</sub>O is found to perform better in enhancing the crop yield. Irrigation at 1.0 Epan and Fertigation with 100% R D of N & K<sub>2</sub>O is effective way to improve water and nutrient use efficiency.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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