**Effect of different levels of drip irrigation and fertigation on growth and yield of sunflower in a *Vertisol* of Karnataka**

**Abstract:** Irrigation and fertilization are two of the most important methods through which farmers can manage productivity. Among various factors responsible for low yield in sunflower, management of fertilizers may be of much importance. A field experiment was conducted to study the “effect of levels of drip irrigation and fertigation on growth and yield of sunflower in a *Vertisol*”. The experiment was laid out in a strip plot design which was replicated thrice, with three main plots *viz*., surface drip irrigation at 0.6, 0.8 and 1.0 IW/CPE ratio and three sub plots *viz*., fertigation of 75 % RDF (F1) (67.5: 67.5: 45 kg N, P2O5 and K2O ha-1), 100 % RDF (F2) (90: 90: 60 kg N, P2O5 and K2O ha-1) and 125 % RDF (F3) (112.5: 112.5: 75 N, P2O5 and K2O ha-1) and control *i.e* surface furrow irrigation and manual fertilizer application of 100 % RDF. Drip irrigation at 1.0 IW/CPE ratio recorded significantly higher seed yield (34.4 q ha-1) and application of fertilizers at 125 % RDF (F3) through fertigation recorded higher seed yield (33.8 q ha-1). Interaction of drip irrigation at 1.0 IW/CPE ratio along with 125 % RDF (I3F3) recorded higher seed yield (36.9 q ha-1). However, manual application of 100 % RDF along with surface furrow irrigation recorded significantly lower growth attributes, yield attributes and seed yield.

**Keywords:** Sunflower, Drip irrigation, Fertigation, IW/CPE ratio, Sunflower

**Introduction**

“Water management in agriculture would play a key role in enhancing agricultural productivity and doubling farmer's income. Despite remarkable achievements in agricultural production, critical challenges still exist with respect to management of land and water resources in the country. Growing population and urbanization led to decline in cultivable land, thereby increasing pressure on land and water resources. Around 70 per cent of freshwater withdrawals go into agriculture. The uses within the sector are very diverse and include mainly irrigation. With a growing food demand, agriculture production will need to expand by 70 per cent by 2050. Given that, irrigated agriculture can be up to twice as productive as rainfed cultivation systems, it is certain that water consumption for agriculture will keep growing. This will allow using land more efficiently, allow for more secure crop diversification, and provide an important buffer against climate variability. Therefore, water scarcity should be coped with ways to reducing water losses, increase in water productivity by producing more crop per volume of water applied. This is only attainable with effective water management methods and the use of modern irrigation technologies such as drip irrigation. Drip irrigation (DI) is an efficient method of irrigation that reduces water scarcity problems and benediction for farmers due to high water use efficiency and water productivity” (Banik *et al.,* 2024). “The combination of drip irrigation and fertilization (fertigation) expands the possibilities of controlling water and nutrient supplies to crops and maintaining the desired concentration and distribution of ions and water in the soil” (Yosef, 1999).

“The oilseeds contribute significantly to agricultural economy in India. Presently, in India the production of oilseeds is not up to the demand due to rapidly increasing population, high living standard with increased purchasing power of population. So, the country is forced to import edible oil from other countries which involves high expenditure in foreign exchange. Therefore, it is very essential to increase the productivity of oilseed crops to cope up with the present demand. The maximum inherent potential of a variety can only be achieved when nutrients are applied in balanced form with recommended dose of fertilizers (RDF)” (Murali *et al.,* 2009). “Drip fertigation improves yield, water and fertilizer use efficiency by sunflower crop by fulfilling the crop demand for water and nutrients throughout the crop period” (Reddy, 2018). Keeping these points in view, the present study was conducted to know “effect of levels of drip irrigation and fertigation on growth and yield of sunflower in a *Vertisol*”.

**Materials and method**

The experiment was conducted at Irrigation Water Management Research Centre (IWMRC), Belvatagi, Navalagund taluk of Dharwad district. The experimental site is situated in the Northern dry zone (Zone-3) of Karnataka. It is located at a latitude of 15o161 North latitude, 75o231 East longitude with an altitude of 579 m above mean sea level. The soil was clay in texture, alkaline in reaction (pH=8.25), normal in salt content (0.31 dS m-1), low in available nitrogen (183.0 kg ha-1), medium in available phosphorus (33.30 kg ha-1) and high in available potassium content (742.0 kg ha-1). The experiment was laid out in strip plot design with three main plots *viz*., surface drip irrigation at 0.6 PE (I1), 0.8 PE (I2) and 1.0 PE (I3) and three sub plots *viz*., fertigation of 75 % RDF (F1) (67.5: 67.5: 45 kg N, P2O5 and K2O ha-1), 100 % RDF (F2) (90: 90: 60 kg N, P2O5 and K2O ha-1) and 125 % RDF (F3) (112.5: 112.5: 75 N, P2O5 and K2O ha-1) and a control *i.e.* surface furrow irrigation and manual fertilizer application of 100 % RDF replicated thrice.

**Quantity of water applied**

The required quantity of water per plot based 0.6, 0.8 and 1 IW/CPE ratio which was calculated by using USWB open pan evaporimeter and irrigation was given at five days interval. There were two lateral for each plot with spacing of 60 cm apart which is running along the length of plot. Drippers of 4 lph capacity were fitted at 40 cm spacing along the lateral line. Ventury was installed in the sub-line for fertigation. Individual control valves were provided for each treatment for imposing different fertigation treatments.

**Note**: Source of fertilizers used in fertigation are urea (46:0:0), urea phosphate (17:44:0) and muriate of potash (0:0:60) which are completely water soluble, where as in control treatment urea, DAP (18:46:0) and MOP are used.

**Statistical analysis**

Data obtained were subjected to statistical test using the Fischer’s method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in ‘F’ test was P=0.05. Critical difference values were calculated wherever the ‘F’ test was significant

**Result and discussion**

**Growth parameters**

Growth parameters were significantly influenced by varied levels of drip irrigation and fertigation levels. Among levels of drip irrigation, growth parameters *viz*. plant height (161.2 cm), number of green leaves per plant (6.9), leaf area per plant (1017.9 cm2), stem girth (2.14 cm) and dry matter production per plant (105.1 g) at harvest were significantly higher with I3(drip irrigation at 1.0 PE) compared to I1(145.9 cm, 4.9, 765.6 cm2, 1.65 cm and 83.4 g, respectively) and I3 was on par with I2 (155.3 cm, 6.6, 923.5 cm2, 1.90 cm and 96.4 g, respectively. Among levels of fertigation, F3 (125% RDF) recorded significantly higher growth parameters *viz*. plant height (162.2 cm), number of green leaves per plant (6.4), leaf area per plant (947.6 cm2), stem girth (2.08 cm) and dry matter production per plant (100.8 g) over F1(142.1 cm, 5.7, 828.6 cm2, 1.65 cm and 86.7 g, respectively). Among the interactions, I3F3 recorded highest growth parameters viz. plant height (168.6 cm), number of green leaves per plant (7.2), leaf area per plant (710.0 cm2), stem girth (2.46 cm) and dry matter production per plant (109.8 g) over other interactions (Table 1 and 2). Frequent application of fertilizers and water through drip fertigation might have led to effective utilization of nutrients due to direct contact with root system and least loss of nutrients through leaching resulting in higher growth attributes. These results are in line with the findings of Karam *et al*. (2007), Jaleel *et al*. (2009), Sanju *et al*. (2013), Mounika (2016) and Himaja (2017). However, control (RPP with surface irrigation) recorded lower growth parameters.

**Yield parameters and yield**

 Yield parameters were significantly influenced by varied levels of drip irrigation and fertigation. Among levels of drip irrigation, drip irrigation at 1.0 PE (I3) recorded highest head weight (64.5 g), head diameter (16.1 cm), number of seeds per head (1008.9) and 100- seed weight (5.3 g) when compared to I1 *i.e.* drip irrigation at 0.6 PE (49.1 g, 13.4 cm, 860.0 and 4.6 g, respectively) and I3 was on par with I2 (60.8 g,15.0 cm, 964.4 and 5.1 g, respectively). Among levels of fertigation, Fertigation of 125 % RDF (F3) through drip recorded significantly higher head weight (62.4 g), head diameter (15.8 cm), number of seeds per head (1005.8) and 100- seed weight (5.4 g) over drip fertigation of 75 % RDF (F1) (52.0 g, 13.7cm, 872.7 and 4.5 g, respectively) and F3 was on par with F2 *i.e.* drip fertigation of 100 % RDF (60.8 g, 15.0 cm, 955.0 and 5.1 g, respectively). Among the interactions, drip irrigation at 1.0 PE along with 125 % RDF (I3F3) recorded significantly higher head weight (70.8 g), head diameter (17.0 cm), number of seeds per head (1050.2) and 100- seed weight (5.6 g) (Table 3 and 4).This might be because of maintenance of optimum soil moisture in the upper 60 cm of soil depth for entire crop period which helped in maintaining a higher leaf water potential and photosynthetic efficiency leading to production of higher head diameter and application of water equivalent to that lost in pan evaporation produced maximum capitulum diameter with bold seeds. These results are supported by the findings of Buriro (2005), Gandahi and Oad (2005), Khaliq*et al*. (2005), Mehmet *et al*. (2013) and Himaja (2017).

Among levels of drip irrigation, drip irrigation at 1.0 PE (I3) recorded higher seed yield (34.4 q ha-1) which was found on par with drip irrigation at 0.8 PE (32.5 q ha-1) but was significantly superior over drip irrigation at 0.6 PE (27.6 q ha-1). Among levels of fertigation, fertigation of 125 % RDF (F3) through drip recorded significantly higher seed yield (33.8 q ha-1) which was found on par with fertigation of 100 % RDF (31.5 q ha-1). However, F3 was significantly superior over fertigation of 75 % RDF (29.1 q ha-1). Among the interactions, drip irrigation at 1.0 PE along with 125 % RDF (I3F3) recorded significantly higher seed yield (36.9 q ha-1) which was found on par with I3F2 *i.e.* drip irrigation at 1.0 PE along with 100% RDF (33.7 q ha-1). Optimum levels of irrigation and fertilizers through drip irrigation showed that the NPK uptake was higher due to frequent application of water and fertilizer with low concentrations and efficient utilization as they were directly placed into the root zone as compared to other irrigation methods. The drip irrigation with optimum levels maintained the balance ratio between supply and required uptake of nutrients which results in higher shoot and root growth of the plant and provides better nutrient uptake from the soil with minimal losses (Singh *et al.,* 2023). These results are in line with the findings of Vasu (2011), Sanju (2013), Himaja (2017) and Reddy (2018), (Damor *et al.,* 2021). However,control (RPP with surface irrigation) recorded lower yield parameters.

**Conclusion**

It is concluded that, Drip irrigation at 1.0 PE recorded significantly higher seed yield (34.4 q ha-1). Application of fertilizers at 125 % RDF (F3) through fertigation recorded higher seed yield (33.8 q ha-1). Interaction of drip irrigation at 1.0 PE along with 125 % RDF (I3F3) recorded higher seed yield (36.9 q ha-1), which was 58.3 per cent higher compared to recommended dose of fertilizers. Therefore drip irrigation at 1.0 PE and 125 % RDF in drip will be followed in order to exploit its maximum yield potential of sunflower crop.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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**Table 1. Influence of drip irrigation and fertigation levels on plant height, number of green leaves per plant and leaf area per plant of sunflower at harvest**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Plant height (cm)** | **No. of green leaves** | **Leaf area (cm2)** |
| **Drip irrigation levels (I)** |
| I1 : DI at 0.6 PE | 145.9b | 4.9b | 765.6b |
| I2 : DI at 0.8 PE | 155.3ab | 6.6a | 923.5a |
| I3 : DI at 1.0 PE | 161.2a | 6.9a | 1017.9a |
| S.Em. ± | 2.7 | 0.16 | 30.1 |
| **Fertigation levels (F)** |
|  F1 : 75 % RDF  | 142.1b | 5.7b | 828.6b |
| F2 : 100 % RDF  | 158.1a | 6.2ab | 930.8a |
| F3 : 125 % RDF  | 162.2a | 6.4a | 947.6a |
| S.Em. ± | 3.6 | 0.1 | 24.2 |
| **Interaction (I×F)** |
| I1F1 : DI at 0.6 PE and 75 % RDF  | 137.4c | 4.6d | 711.2b |
| I1F2 : DI at 0.6 PE and 100 % RDF  | 149.3a-c | 4.9d | 786.0b |
| I1F3 : DI at 0.6 PE and 125 % RDF  | 151.0a-c | 5.3cd | 799.6b |
| I2F1 : DI at 0.8 PE and 75 % RDF  | 142.4c | 6.0bc | 791.6b |
| I2F2 : DI at 0.8 PE and 100 % RDF  | 156.5a-c | 6.8ab | 979.9a |
| I2F3 : DI at 0.8 PE and 125 % RDF  | 167.0ab | 6.9a | 998.9a |
| I3F1 : DI at 1.0 PE and 75 % RDF  | 146.4bc | 6.5ab | 982.9a |
| I3F2 : DI at 1.0 PE and 100 % RDF  | 168.5a | 6.9a | 1026.4a |
| I3F3 : DI at 1.0 PE and 125 % RDF  | 168.6a | 7.2a | 1044.3a |
| **Control (C)**  | 134.3c | 4.5d | 710.0b |
| S.Em. ± | 6.7 | 0.3 | 43.0 |

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P= 0.05)

**Note:**

DI – Drip irrigation

RDF – Recommended dose of fertilizers

75 % RDF – 67.5:67.5:45 kg N, P2O5 and K2O ha-1

 100 % RDF - 90:90:60 kg N, P2O5 and K2O ha-1

125 % RDF - 112.5:112.5:75 N, P2O5 and K2O ha-1

Control – Recommended package of practice

**Table 2. Influence of drip irrigation and fertigation levels on stem girth and dry matter production of sunflower at harvest**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Stem girth (cm)** | **Dry matter production (g)** |
| **Drip irrigation levels (I)** |
| I1 : DI at 0.6 PE | 1.65b | 83.4b |
| I2 : DI at 0.8 PE | 1.90ab | 96.4a |
| I3 : DI at 1.0 PE | 2.14a | 105.1a |
| S.Em. ± | 0.06 | 3.46 |
| **Fertigation levels (F)** |
|  F1 : 75 % RDF  | 1.65b | 86.7b |
| F2 : 100 % RDF  | 1.97a | 97.3ab |
| F3 : 125 % RDF  | 2.08a | 100.8a |
| S.Em. ± | 0.06 | 2.7 |
| **Interaction (I×F)** |
| I1F1 : DI at 0.6 PE and 75 % RDF  | 1.56cd | 77.9c |
| I1F2 : DI at 0.6 PE and 100 % RDF  | 1.61c | 84.6bc |
| I1F3 : DI at 0.6 PE and 125 % RDF  | 1.79bc | 87.7bc |
| I2F1 : DI at 0.8 PE and 75 % RDF  | 1.75bc | 85.2bc |
| I2F2 : DI at 0.8 PE and 100 % RDF  | 1.97b | 99.2ab |
| I2F3 : DI at 0.8 PE and 125 % RDF  | 1.99b | 104.9a |
| I3F1 : DI at 1.0 PE and 75 % RDF  | 1.65c | 97.2ab |
| I3F2 : DI at 1.0 PE and 100 % RDF  | 2.32a | 108.2a |
| I3F3 : DI at 1.0 PE and 125 % RDF  | 2.46a | 109.8a |
| **Control (C)**  | 1.3d | 75.2c |
| S.Em. ± | 0.09 | 4.6 |

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P= 0.05)

 **Note:**

DI – Drip irrigation

RDF – Recommended dose of fertilizers

75 % RDF – 67.5:67.5:45 kg N, P2O5 and K2O ha-1

100 % RDF - 90:90:60 kg N, P2O5 and K2O ha-1

125 % RDF - 112.5:112.5:75 N, P2O5 and K2O ha-1

Control – Recommended package of practice

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Head weight****(g)** | **Head diameter** **(cm)** | **No. of seeds per head** |
| **Drip irrigation levels (I)** |
| I1 : DI at 0.6 PE | 49.1b | 13.4b | 860.0b |
| I2 : DI at 0.8 PE | 61.6a | 15.0a | 964.4a |
| I3 : DI at 1.0 PE | 64.5a | 16.1a | 1008.9a |
| S.Em. ± | 1.5 | 0.4 | 26.1 |
| **Fertigation levels (F)** |
| F1 : 75 % RDF  | 52.0b | 13.7b | 872.7a |
| F2 : 100 % RDF  | 60.8a | 15.0ab | 955.0ab |
| F3 : 125 % RDF  | 62.4a | 15.8a | 1005.8a |
| S.Em. ± | 2.1 | 0.4 | 25.4 |
| **Interaction (I×F)** |
| I1F1 : DI at 0.6 PE and 75 % RDF  | 42.8e | 12.4b | 770.6c |
| I1F2 : DI at 0.6 PE and 100 % RDF  | 48.5de | 13.6b | 891.9bc |
| I1F3 : DI at 0.6 PE and 125 % RDF  | 55.9cd | 14.0b | 917.6ab |
| I2F1 : DI at 0.8 PE and 75 % RDF  | 57.7c | 13.9b | 893.3bc |
| I2F2 : DI at 0.8 PE and 100 % RDF  | 60.4bc | 14.8ab | 950.5ab |
| I2F3 : DI at 0.8 PE and 125 % RDF  | 66.6ab | 16.4a | 1049.6a |
| I3F1 : DI at 1.0 PE and 75 % RDF  | 55.4cd | 14.8ab | 954.1ab |
| I3F2 : DI at 1.0 PE and 100 % RDF  | 67.3ab | 16.5a | 1022.4ab |
| I3F3 : DI at 1.0 PE and 125 % RDF  | 70.8a | 17.0a | 1050.2a |
| **Control (C)**  | 39.9e | 12.4b | 762.3c |
| S.Em. ± | 2.7 | 0.7 | 45.5 |

**Table 3. Influence of drip irrigation and fertigation levels on head weight, head diameter and number of seeds per head of sunflower**

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P= 0.05)

**Note:**

DI – Drip irrigation

RDF – Recommended dose of fertilizers

75 % RDF – 67.5:67.5:45 kg N, P2O5 and K2O ha-1

100 % RDF - 90:90:60 kg N, P2O5 and K2O ha-1

125 % RDF - 112.5:112.5:75 N, P2O5 and K2O ha-1

Control – Recommended package of practice

**Table 4. Influence of drip irrigation and fertigation levels on 100-seed weight and seed yield of sunflower crop.**

|  |  |  |
| --- | --- | --- |
| **Treatment** | **100-seed weight (g)** | **Seed yield****(q ha-1)** |
| **Drip irrigation levels (I)** |
| I1 : DI at 0.6 PE | 4.6b | 27.6b |
| I2 : DI at 0.8 PE | 5.1a | 32.5a |
| I3 : DI at 1.0 PE | 5.3a | 34.4a |
| S.Em. ± | 0.1 | 0.7 |
| **Fertigation levels (F)** |
|  F1 : 75 % RDF  | 4.5b | 29.1b |
| F2 : 100 % RDF  | 5.1ab | 31.5ab |
| F3 : 125 % RDF  | 5.4a | 33.8a |
| S.Em. ± | 0.6 | 0.9 |
| **Interaction (I×F)** |
| I1F1 : DI at 0.6 PE and 75 % RDF  | 4.1ef | 23.6d |
| I1F2 : DI at 0.6 PE and 100 % RDF  | 4.5de | 27.9c |
| I1F3 : DI at 0.6 PE and 125 % RDF  | 5.2a-c | 31.2bc |
| I2F1 : DI at 0.8 PE and 75 % RDF  | 4.7cd | 31.0bc |
| I2F2 : DI at 0.8 PE and 100 % RDF  | 5.2a-c | 33.0ab |
| I2F3 : DI at 0.8 PE and 125 % RDF  | 5.4ab | 33.4ab |
| I3F1 : DI at 1.0 PE and 75 % RDF  | 4.8b-d | 32.5b |
| I3F2 : DI at 1.0 PE and 100 % RDF  | 5.6a | 33.7ab |
| I3F3 : DI at 1.0 PE and 125 % RDF  | 5.6a | 36.9a |
| **Control (C)**  | 3.6f | 22.3d |
| S.Em. ± | 0.2 | 1.2 |

Means followed by the same alphabet (s) within a column are not significantly differed by DMRT (P= 0.05)

**Note:**

DI – Drip irrigation

RDF – Recommended dose of fertilizers

75 % RDF – 67.5:67.5:45 kg N, P2O5 and K2O ha-1

100 % RDF - 90:90:60 kg N, P2O5 and K2O ha-1

125 % RDF - 112.5:112.5:75 N, P2O5 and K2O ha-1

Control – Recommended package of practice