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Response of growth and yield of hybrid sunflower to deficit irrigation under drip system

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Abstract
A field experiment was conducted at Agricultural College and Research Institute, Madurai, TNAU, Tamil Nadu, during *rabi* season (2017 – 2018) to study the effects of deficit irrigation (DI) on growth and yield of sunflower under drip system. The experiment was laid out in Randomized block design with three replication, used TNAU sunflower hybrid Co2 as a test crop. The treatments comprised of conventional drip irrigation at 100% ET_c (T_1) and 75% ET_c (T_2), Irrigation at 100% and 75% ET_c as alternate irrigation cycle (T_3), Irrigation at 75% ET_c in alternate irrigation cycle (skip) (T_4), T_5, T_6 and T_7 - Irrigation at 75% ET_c skip during button initiation, flowering and seed filling, respectively. The growth parameters of plant height, dry matter production and growth analysis of leaf area index and crop growth rate and seed and stalk yield were recorded. Results indicated that deficit irrigation treatments significantly reduced the plant growth parameters and yield. Among the different treatments, the higher growth parameters were registered with drip irrigation at 100 % ET_c (T_1). Maximum seed and stalk yield was achieved in the same treatment. The lowest growth parameters and yield was noticed in the irrigation at 75 ET_c in alternate irrigation cycle (T_4)

Keywords: Hybrid sunflower, Deficit irrigation, Drip irrigation, dry matter production, seed yield, stalk yield

1. Introduction

Irrigation water is the major limiting factor in crop production. To sustain the rapidly growing world population, agricultural production will need to increase (Howell, 2001) [9], yet the portion of fresh water currently available for agriculture is decreasing (Cai and Rosegrant, 2003) [3]. Hence, sustainable methods to increase crop water use efficiency and water productivity are gaining importance in arid and semiarid region (Debaeke and Aboudrare, 2004) [4]. Generally, agricultural research has focused primarily on maximizing total production. In recent years, emphasis has shifted to the limiting factors in production systems, notably the availability of water. Deficit irrigation (DI) has been widely investigated as a valuable strategy where water is the limiting factor in crop production (Fereres and Soriano, 2007) [6]. The application of water below the ET requirements is termed as deficit irrigation (DI). Deficit irrigation is an optimization strategy of irrigation water. Therefore, water demand for irrigation can be reduced and the water saved can be diverted for alternative uses. The goal of deficit irrigation is to increase crop water use efficiency (WUE) by reducing the amount of water at irrigation or by reducing the number of irrigation events (Kirda, 2002) [12]. Crop such as cotton, maize, groundnut, wheat, sunflower and sugarbeet can adapt well to deficit irrigation practices provide good management practices can be secured (Kang and Chai, 2002) [10]. Sunflower is one of the leading oil seed crop of the world. In India, during 2017 it is cultivated 490 m.ha. With production of 296 million tonnes and productivity of 608 kg ha^{-1} (Indiastat, 2016-17). In Tamil Nadu it is grown on area of 8.3 m.ha. With a production of 8.80 million tonnes and productivity of 1060 kg ha^{-1} (Indiastat, 2015-16). Sunflower seeds contain a high amount of oil (40 to 50%) which is an important source of polyunsaturated fatty acid (linoleic acid) of potential health benefits (Lopez *et al.,* 2000 [14]; Leon *et al.,* 2003 [13]; Monotti, 2004 [15]). Sunflower is considered to be tolerant to water deficit to some extent (Yawson *et al.,* 2011) [22]. Therefore, knowledge of the effects of irrigation scheduling on sunflower production and water productivity under water stress conditions is becoming increasingly important.

Materials and Methods

The field experiment was conducted at *rabi* season of 2017 – 2018 at Agricultural College and

Research Institute, Madurai, TNAU, Tamil Nadu. The experimental site is situated at 9°54' N latitude and 78°54' 'E' longitude and at an altitude of 147 m above mean sea level.

The experimental site is characterized by tropical climate with mean annual rainfall of 856 mm, out of which 39.8 per cent is distributed during south west monsoon (June-September), 42 per cent during north east monsoon (October - December), 2.1 per cent during winter (January- February) and 16.2 per cent during summer (March-May). The soil of the experimental field is sandy clay loam in texture. The fertility status was low in available nitrogen (245 kg ha^{-1}), medium in available phosphorus (17 kg ha^{-1}), and high in available potassium (343 kg ha^{-1}) and neutral in reaction.

The experiment was laid out in randomized block design, replicated thrice using hybrid TNAU sunflower hybrid Co2 as a test crop. The experiment was carried out with the following treatments *viz.,* Conventional drip irrigation at 100% ET_c (T_1) and 75% ET_c (T_2), Irrigation at 100% and 75% ET_c as alternate irrigation cycle (T_3), Irrigation at 75% ET_c in alternate irrigation cycle (skip) (T_4), T_5, T_6 and T_7 - Irrigation at 75% ET_c skip during button initiation, flowering and seed filling, respectively.

The recommended fertilizer dose of 60:90:50 kg of N, P_2O_5 and K_2O ha^{-1} was applied to all the treatments. Nitrogen and Potassium were applied through drip fertigation in the form of urea (46 % N) and muriate of potash (60 % K_2O), respectively. Full dose of P was applied in the form of single super phosphate (16% P_2O_5) as basal.

Irrigation was done based on crop evapotranspiration (ET_c). Drip irrigation system was operated once in three days.

Water requirement or $ET_c = CPE \times K_P \times K_c \times W_p \times S$

Where,

CPE- Cumulative Pan Evaporation (mm), K_P-Pan coefficient (0.8), K_c- Crop co-efficient, W_p – Wetting area percentage (80 per cent), S – Crop spacing (0.6 m × 0.3 m).

Crop coefficient values of sunflower

Crop stage	Sunflower	
	Duration (days)	**K_c value**
Initial	15	0.35
Development	20	0.75
Mid-season	30	1.13
Late season	25	0.75

Results and Discussion

Plant height

The result showed that, the plant height of sunflower was significantly affected due to deficit irrigation (Table.1). Drip irrigation with 100 per cent ET_c throughout the cropping period (T_1) produced higher plants at all the three stages of observations. The plant height of 88.92, 153.7 and 160.1 cm recorded at 30, 60 and at harvest respectively. It was on par with irrigation at 100 per cent and 75 per cent ET_c as alternate irrigation cycle (T_3) and it was significantly differed from water stress at critical stages (button initiation, flowering and seed filling) (T_5, T_6, T_7). Shorter plants (57.11, 110.9 and 115.2 cm) were observed in severe water stressed (T_4) plots and it was significantly differed from the other treatments. The plant height recorded in T_2, T_6 and T_7 was on par at harvest. It was due to deficit irrigation at after flowering and seed filling stage the plant height was not significantly differed. These results are agreed with the findings of Razi and Assad (1999) [16]. Soriano *et al.* (2004) [19] reported that adequate irrigation lead to increase of plant height of sunflower.

Dry matter production

Dry matter accumulation was significantly influenced by the deficit irrigation practices at all the three stages of observation (Table.1). Irrigation at 100 per cent ET_c throughout the cropping period (T_1) registered significantly higher dry matter as compared to other treatments. Higher values of dry matter production, 1739, 5893 and 6995 kg ha^{-1} was observed in T_1 at 30, 60 DAS and at harvest and it was on par with T_3 (1667, 5852 and 6677 kg ha^{-1}). Alternate deficit irrigation (T_3) was on par with T_2 and significantly differ from T_5, T_6, T_7 and lowest value (789, 3056, 3268 kg ha^{-1}) was recorded in irrigation at 75 per cent ET_c (Skipping one cycle, T_4). Water stress during bud initiation stage (T_5) recorded dry matter production of 1247, 3817 and 5389 kg ha^{-1} and it was significantly differed from 100 per cent ET_c (T_1). Water deficit during bud initiation stage caused significant reduction in total dry matter compared to full irrigation. These results agree with the earlier findings of Turhan and Baser (2004) [21] and Geetha *et al.* (2012) [7].

Table1: Effect of deficit irrigation on plant height (cm), dry matter production (kg ha^{-1}) of sunflower

Treatments	Plant height (cm)			Dry matter production (kg ha^{-1})		
	30 DAS	**60 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**At harvest**
T_1	88.9	153.7	160.1	1739	5893	6995
T_2	68.9	138.3	141.1	1296	4858	6085
T_3	88.3	152.8	158.5	1667	5852	6677
T_4	57.1	110.9	115.2	789	3056	3268
T_5	65.7	120.6	121.0	1247	3817	5389
T_6	66.7	129.2	135.6	1257	4050	5260
T_7	68.7	135.3	140.3	1261	4650	5873
SEd	3.7	6.0	6.1	66	219	258
CD (p=0.05)	8.1	13.2	13.2	143	476	562

Leaf area index

Deficit irrigation had significant influence on the LAI of the crop (Table.2). Maximum LAI of 1.79, 3.45 was recorded under T_1 at 30 and 60 DAS, respectively and it was significantly differ from other treatments and due to severe water stress lower (0.60, 0.94) LAI was recorded in T_4 at 30 and 60 DAS, respectively. This might be due to water stress imposed during vegetative period reduced the number and expansion growth of leaves and caused lower LAI and also stress occur at flowering result in greater reduction in leaf area development. Our results are in agreement with the findings of Sadras *et al*. (1991) [17] and Hasio (1973) [8].

Table 2: Effect of deficit irrigation on leaf area index and crop growth rate (kg ha^{-1}), seed yield (kg ha^{-1}), stalk yield (kg ha^{-1})

Treatments	Leaf area index		Crop growth rate (kg ha^{-1})		Seed yield (kg ha^{-1})	Stalk yield (kg h^1)
	30 DAS	60 DAS	30-60 DAS	60 DAS- At harvest		
T_1	1.79	3.45	5835	6799	2307	4586
T_2	1.19	1.82	4815	5923	1868	3846
T_3	1.54	2.37	5796	6481	2029	4206
T_4	0.60	0.94	3029	3166	909	2546
T_5	1.00	1.42	3775	5262	1601	3322
T_6	1.06	1.35	4008	5125	1485	3146
T_7	1.12	1.68	4608	5718	1667	3490
SEd	0.1	0.2	219	259	118	224
CD (p=0.05)	0.2	0.3	477	565	257	489

Crop growth rate

The crop growth rate was markedly influenced by the deficit irrigation practices (Table.2). Growth rate increased with age of the crop as that of dry matter production and maximum CGR recorded at 60 DAS to harvest stage. Drip irrigation at 100 per cent ET_c (T_1) performed higher CGR values at 30-60 DAS and 60 – harvest stage (5835 kg ha^{-1} and 6799 kg ha^{-1}) and the same was on par with 100 per cent ET_c and 75 per cent ET_c as alternate irrigation cycle (T_3). Deficit irrigation at 75 ET_c (T_4) resulted in lower CGR value in 30-60 DAS and 60- at harvest (3029 kg ha^{-1} and 3166 kg ha^{-1}) compared to other treatments. Sinclair and Ludlow (1986) [18] and Subbarao *et al.* (2000) [20] was observed that water stress causes reduction in leaf photosynthesis and directly affects CGR values.

Seed Yield

The seed yield of sunflower was significantly influenced due to deficit irrigation (Table 2). The highest seed yield (2307 kg ha^{-1}) was recorded at 100 per cent ET_c (T_1) throughout the cropping period and it was significantly differed from other treatments. However it was followed by T_3 and T_2 which produced more grain yield but the difference were comparable with each other. Drastic reduction of yield (909 kg ha^{-1}) was observed under severe water stressed treatment (T_4). Water stress during flowering produced less yield (1485 kg ha^{-1}) compared to water stress during button initiation (1601 kg ha^{-1}) and seed filling (1667 kg ha^{-1}). Ali and Shui (2009) [2] also reported that flowering period is the most sensitive to water deficit which cause considerable yield reduction. Seed formation is the next most sensitive to water deficit, causing severe reduction in yield (Doorenbos and Kassam, 1979) [5].

Stalk yield was favorably influenced by deficit irrigation. The higher stalk yield (4585 kg ha^{-1}) was recorded with drip irrigation scheduled at 100 per cent ET_c. It was on par with alternate deficit irrigation with 100 per cent ET_c and 75 per cent ET_c (T_3). The lowest stalk yield 3267.84 kg ha^{-1} was observed under severe water stressed treatment (T_4). Alahdadi *et al*. (2011) [1] and Kassab *et al*. (2012) [11] also reported that, decreasing the amount of irrigation water applied significantly reduced the stalk yield and ultimately biological yield of sunflower.

Conclusion

From the results it could be concluded that, the highest growth parameters and yield was obtained from drip irrigation at 100 per cent ET_c throughout the cropping period. Water stress given at critical periods has poor performance compared to others. Flowering and seed filling is most sensitive to water stress.

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