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Water Use and Yield of Sunflower (*Helianthus annuus* L.) as Influenced by Irrigation, Mulch and Cycocel Application*

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To find out the effect of four schedules of irrigation, 50 mm irrigation based on IW/PAN-E ratio of 0.5, 0.7, 0.9 and 1.1; two rates of stover mulch, 0 and 20 t/ha and two concentrations of cycocel, 0 and 0.03 per cent on the yield and water use of sunflower, a field experiment was conducted on clay loam soil during summer 1976 and 1977. Scheduling irrigation based on IW/PAN-E ratio of 0.7 for entire season gave maximum seed yield with higher water use efficiency. Stover mulching in summer increased the crop yields with greater water use efficiency. The retarding effect of cycocel on morphological characters ultimately minimized water use and helped in boosting up the seed yield.

Among the various approaches used for scheduling irrigation to different crops, a modified meteorological approach based on the ratio of fixed amount of irrigation (IW) to pan evaporation (PAN-E) has been found most suitable as a practical guide for scheduling irrigation to various crops (Prihar *et al.*, 1976 and Khera *et al.*, 1976). Stover mulching is known to influence hydrothermal regime which is likely to reduce evaporation losses from the soil surface, affect N mineralization and thereby increase yield and water use efficiency of crops (Myer, 1975 and Chaudhary and Prihar, 1974). Regulation of plant growth by using chemical retardants has opened new vistas in the field of plant moulding. Foliar application of growth retardants like cycocel has been proved most effective in this direction.

MATERIAL AND METHODS

A two year field study was conducted to investigate the effect of irrigation, mulching and cycocel on yield and water use by sunflower grown on clay loam soil of Agronomy Farm of Rajasthan College of Agriculture, University of Udaipur during summer seasons of 1976 and 1977. Soil physical parameters for both the years are given in Table I. Total rainfall and open pan evaporation during growing season were 4.7 and 834.4 mm in 1976 and 32.1 and 835.5 mm in 1977, respectively.

The sixteen treatments comprised all combinations of four schedules of irrigation IW/PAN-E ratios of 0.5, 0.7, 0.9 and 1.1, two rates of mulch, 0 and 20 t of stover/ha and two concentra-

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TABLE I. Value of soil physical parameters at different soil depths

	Soil depth (cm)					
	C 5 Plot (1976)			A 2 Plot (1977)		
	0—15	15—30	30—45	0—15	15—30	30—45
Field capacity (%)	26.9	24.7	24.7	23.7	23.7	23.3
Permanent wilting point (%)	12.7	10.3	10.1	11.2	9.5	9.2
Bulk density g/cm^3	1.35	1.38	1.27	1.49	1.57	1.46

tions of water (IW) and cumulative pan evaporation less rainfall since previous irrigation (PAN-E). Combination of irrigation and mulch treatments constituted the main plot and cycocel in sub-plot treatments in a split plot design replicated four times in 6 x 5 m plots. Sunflower stover chaffed into small pieces was used as mulch. Immediately after seeding, sunflower stover mulch was applied @ 20 t/ha which gave a layer about 7.5 cm after settling. Cycocel was sprayed at the concentration of 0.03 per cent @ 1000 l/ha as foliar spray at seventh leaf stage. The crop was planted on 28th February 1976 and 15th March 1977 and harvested on 5th June 1976 and June 1977 respectively. The soil moisture content upto 120 cm was determined thermo-gravimetrically at sowing, before and after each irrigation and at harvest. Irrigation water was measured with a 7.5 cm parshall flume installed in the water channel in experimental field. The dates of irrigation to various treatments are indicated in Table II.

The water use was computed as the sum of profile soil moisture use, effective rainfall and ground water contribution. Water use efficiency was calculated as the quantity of seed produced kg/ha per cm of water use.

RESULTS AND DISCUSSION

Yield

Effect of IW/PAN-E, ratio: Irrigation schedule based on IW/PAN-E of 0.7 established its superiority by yielding 2298, 2210 and 2254 kg/ha of seed yield as compared to other ratios in the year 1976, 1977 as well as in pooled results, respectively followed by IW/PAN-E of 1.1 and 0.9 in 1976 and 0.9 and 1.1 in 1977 as well as in pooled results which did not differ significantly among themselves (Table III). These findings would show that an irrigation schedule based on IW/PAN-E of 0.7 secured a seed yield as high as that of higher ratios of 0.9 and 1.1. Relative constancy in seed yield with further increase in IW/PAN-E ratio from 0.7 to 1.1, indicates that IW/PAN-E ratio greater than 0.7 may not be useful for increasing the yield of sunflower. Yields obtained in both the years were highest under IW/PAN-E of 0.7 which evidently has resulted from higher filled seed per

TABLE II. Dates of irrigation application and total water applied to four IW/PAN-E ratios during 1976 and 1977

	IW/PAN-E ratio							
	1976				1977			
Dates of irrigation	0.5	0.7	0.9	1.1	0.5	0.7	0.9	1.1
I	19 March	15 March	12 March	10 March	31 March	27 March	25 March	23 March
II	2 April	23 March	20 March	18 March	14 April	6 April	2 April	30 March
III	15 April	2 April	28 March	24 March	26 April	16 April	10 April	7 April
IV	27 April	12 April	5 April	31 March	7 May	25 April	18 April	14 April
V	8 May	21 April	13 April	7 April	17 May	3 May	24 April	20 April
VI	20 May	29 April	20 April	14 April	26 May	10 May	1 May	25 April
VII		7 May	26 Aptil	20 April		17 May	7 May	30 April
VIII		15 May	3 May	25 April		24 May	13 May	5 May
IX			9 May	30 April			18 May	10 May
X			16 May	5 May			23 May	15 May
XI				10 May				2n May
XII				16 May				24 May
Total No. of irrigation	6	8	10	12	6	8	10	12
Total quantity of water applied (ha cm)	10	40	50	60	30	40	50	60

cent, seed weight per head and seed index (Table IV). These are the important yield components which showed significant positive correlation with seed yield. The higher LAI and lower lodging per cent (Table IV) may also have contributed towards the higher seed yield. Thus, from all the measurable sources evaluated in the present study it is shown that irrigation schedule based on IW/PAN-E of 0.7 (Total 8 irrigations) was the best for higher seed yield of sunflower. Surajbhan (1976) also suggested 8 to 10 irrigations for optimum seed yield of summer sunflower in central tract of U.P.

Effect of mulch : Application of mulch tended to be advantageous in increasing the seed yield by 195 kg/ha over no mulch. Use of mulch facilitates better mineralization and availability of nutrients which enhanced their uptake as well as utilization in improving or

TABLE III. Effect of irrigations, mulching and cycocel on the water use, yield and water use efficiency of sunflower in 1976 and 1977

	Water use (cm)			Yield (kg/ha)			Water use efficiency (kg seed/ha/cm)		
Treatments	1976	1977	Mean	1976	1977	Mean	1976	1977	Mean
W/PAN-E ratio									
0.5	26.8	24.6	25.7	1969	1863	1916	74.24	74.95	74.59
0.7	28.6	26.4	27.5	2298	2210	2254	80.97	84.93	82.95
0.9	31.3	29.0	30.1	2246	2197	2221	72.75	76.10	74.42
1.1	33.3	31.3	32.3	2256	2149	2202	68.46	68.73	68.59
S.Em. ±	0.10	0.05	0.27	18.33	21.49	66.41	0.67	0.66	2.35
C.D. (5%)	0.29	0.17	0.93	54.99	63.33	221.66	1.99	1.95	7.87
Stover mulch (T/ha)									
0(M_0)	32.1	29.5	30.8	2059	2043	2051	64.44	69.15	66.79
20(M_1	27.8	26.1	26.9	2326	2167	2246	83.76	83.21	83.48
S.Em. ±	0.07	0.04	0.19	13.33	15.16	46.91	0.47	0.47	1.66
C.D. (5%)	0.20	0.12	0.66	39.41	44.81	156.66	1.40	1.38	5.56
Cycocel (Conc. %)									
0(Co)	30.7	28.4	29.5	2080	2001	2040	68.56	69.99	69.27
0.03(C1)	29.2	27.2	28.2	2305	2209	2257	79.65	81.96	80.80
S.Em. ±	0.07	0.03	0.06	10.83	21 99	58.33	0.33	0.78	0.67
C.D. (5%)	0.20	0.10	0.22	32.49	64.34	189.99	0.98	2.29	2.20

favourably modifying the various yield attributes (Table IV) to the better advantage of seed yield.

Effect of cycocel: An Application of CCC resulted in significant increase in mean seed yield of 217 kg/ha over untreated plot. The results demonstrate amply well the functional role of cycocel in regulating the allocation of photosynthates by arresting elongation of stem and diverting them for proper filling up of the seeds which resulted in a higher filled seed per cent, seed index and weight of seed/head (Table IV). A control on lodging incidence brought about by the application of CCC (Table IV) is also responsible for higher seed yield.

Water use and Water use Efficiency

IW/PAN-E, ratio: The mean maximum and minimum water use of 32.3 and 25.7 ha cm was recorded under higher and lower IW/PAN-E of 1.1 and 0.5, respectively (Table III). The higher water use under higher ratio of 1.1 is attributed to the fact that this ratio received maximum water by 60 ha cm. It appears that excessive vegetative growth in terms of plant height and leaf area (Table IV) may be responsible for higher water use.

Irrigation schedule based on IW/PAN-E of 0.7 recorded highest mean water use efficiency by 82.95 which was 21.0 per cent higher than the IW/PAN-E ratio of 1.1. The higher seed yield with lower water use resulted in higher water use efficiency under this ratio.

Mulch : A marked reduction in water use by 12.6 per cent with the aid of mulch was observed in both the years (Table III). Considerable reduction in moisture loss through evaporation may be responsible for decrease in water use of crop with mulch (Gupta, 1975).

Mulch resulted in remarkably increased water use efficiency by 25.0 per cent over no mulch. The findings corroborate the reports of Ali and Prasad (1975).

Cycocel : Water use was significantly reduced with CCC in both the

TABLE IV. Growth characters and yield attributes of sunflower as affected by irrigation, mulching and cycocel application (Mean of two years 1976 and 1977)

Treatments	Plant Height (cm)	Leaf area index	Lodging (%)	Filled Seed (%)	Seed weight per head(g)	Seed index (g)
IW/PAN-E ratio						
0.5	156.00	3.25	16.70	73.20	24.20	51.80
0.7	174.20	4.23	19.80	83.80	33.60	58.90
0.9	178.40	4.15	22.70	80.10	29.70	55.60
1.1	184.00	4.16	25.50	81.10	32.20	58.00
S.Em. ±	2.90	0.05	0.44	1.37	0.86	0.99
C.D. (%)	8.27	0.14	1.26	4.05	2.89	3.31
Stover mulch (t/ha)						
0(M_0)	170.30	3.97	21.50	78.80	29.30	55.70
20(M_1)	175.90	3.93	20.90	80.50	30.50	56.50
SE.m. ±	2.05	0.03	0.31	0.58	0.61	0.50
C.D. (5%)	NS	0.10	NS	NS	NS	NS
Cycocel (Conc %)						
0(Co)	179.90	4.41	24.60	77.50	28.90	54.90
0.03(C1)	166.60	3.49	17.80	81.70	31.00	57.30
S.Em. ±	1.35	0.03	0.22	0.58	0.82	0.50
C.D. (5%)	3.85	0.08	0.63	1.71	NS	1.05

NS = Not significant

years. The mean reduction was 4.4 per cent with CCC treated plots over untreated plots. A significant reduction in vegetative growth (Plant height and leaf area index) with CCC (Table IV) resulted in minimizing the water loss through transpiration thus, culminating its anti-transpirant properties. The reason for reduction in water use with CCC is further attributed to decrease in water uptake by application of CCC (Gohlke and Tolbert, 1962).

Cycocel was also found conducive by increasing significantly the water use efficiency in both the years. The mean increase was 17.1 per cent under CCC treated plots over control. The findings are in accordance with those of Goodin *et al*. (1966). Significantly lower water use coupled with higher seed yield resulted in higher water use efficiency with CCC.

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