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Effect of irrigation management on physiology and productivity of soybean *(Glycine max)*

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ABSTRACT

A field experiment was carried out during summer and monsoon seasons of 1996 using soybean [*Glycine max* (L.) Merr.] 'Co1' with 2 irrigation levels, viz. 0.40 and 0.60 IW : CPE ratio, 3 methods of irrigation, viz. all furrow, alternate furrow and paired row furrow, and 4 management practices comprising coirpith application, KCl 0.5% at peak flowering stage, Kaolin 3% foliar spray at 30,45 and 65 days after sowing and control. The crop growth and yield were better in monsoon than in summer. Irrigation at 0.60 IW : CPE ratio through all furrow method recorded lower canopy temperature, lower transpiration rate, higher relative leaf water content (RLWC) and stomatal diffusive resistance (SDR) which resulted in higher seed yield. All management practices, viz. coirpith, KCl and Kaolin, separately maintained higher tissue water content than in the control.

Key words : Irrigation, Physiology, Productivity, Soybean

The water management improves the yield of crops like soybean because of high susceptibility to water stress at various growth stages. This can be achieved by proper crop management, viz. regulation of transpiration, improving water-use efficiency (WUE) and better root penetration. However, the stress reduces the leaf water potential, stomatal conductance and transpiration rate (Itoh and Kamura, 1996). The present study was therefore conducted to know the effect of irrigation levels, methods and management practices on plant–water relations and their impact on crop productivity.

MATERIALS AND METHODS

A field experiment was carried out at Tamil Nadu Agricultural University, Coimbatore, during summer and monsoon 1996. The soil of experimental field was sandy clay loam. The nutrient status was low in nitrogen, medium in phosphorus and high in potassium. The field capacity and wilting point of soil were 24.5 and 12.1 respectively, the bulk density was 1.30 g/CC; the soil pH 7.9 and EC 7.9 and 0.43 mmhos/cm. Soybean cultivar 'Co.1' with duration of 85–90 days was used as a test crop. Irrigation scheduling was based on the irrigation, water (IW) ratio and cumulative pan evap-

oration (CPE) recorded from USWB class A open pan evaporimeter. The depth or irrigation adopted was 50 mm.

The experiment was laid out in split-plot design with 2 irrigation levels, viz. irrigation at 0.40 (I_1) and 0.60 (I_2) IW : CPE ratio, and 3 methods of irrigation, viz. all furrow (M_1) alternate furrow (M_2) and paired row furrow (M_3), were allotted to main plots and 4 management practices, viz. control (A_0), coirpith application @ 12.5 tonnes/ha (A_1), Kaolin at 3% foliar spray (A_2) at 30, 45 and 65 days after sowing (DAS) and KCl 0.5 during peak flowering stage (A_3), formed the subplot treatments. Recommended package of practices for soybean were adopted.

RESULTS AND DISCUSSION

Higher leaf-area index (LAI) could be recorded in monsoon than in summer. Scheduling irrigation at 0.60 IW : CPE ratio recorded higher LAI, followed by 0.40 IW : CPE ratio (Table 1). Among the methods of irrigation, all furrow irrigation recorded higher LAI, followed by double-row furrow irrigation. The LAI gradually increased from 30 to 60 DAS and then

Table 1. Effect of irrigation levels, methods and management practices on leaf-area index and yield of soybean

Treatment	Leaf-area index				Seed yield (kg/ha)	
	Summer		Monsoon		Summer 1996	Monsoon 1996
	60 DAS	At harvest	60 DAS	At harvest		
Irrigation						
I_1, 0.40 IW : CPE ratio	2.13	1.64	2.63	1.82	1,148	1,296
I_2, 0.60 IW : CPE ratio	3.26	2.12	3.79	2.52	1,560	1,642
CD (P = 0.05)	0.56	0.29	0.67	0.58	116.43	125.59
Method of irrigation						
M_1, all furrow method	3.56	2.66	3.68	2.58	1,443	1,525
M_2, alternate furrow	2.44	1.52	2.36	1.54	1,296	1,378
M_3, paired row or double row furrow	3.15	2.12	3.06	1.96	1,362	1,464
CD (P = 0.05)	0.32	0.22	0.48	0.25	72.56	75.47
Management practice						
A_0, Control	2.88	1.88	3.01	2.03	1,202	1,284
A_1, coirpith application @ 12.5 t/ha	3.54	2.64	3.85	2.79	1,515	1,597
A_2, Kaolin 3% foliar spray	3.14	2.18	3.26	2.79	1,355	1,437
A_3, KCl 0.5% spray	3.30	2.42	3.58	2.48	1,420	1,504
CD (P = 0.05)	0.10	0.14	0.16	0.12	73.25	75.52

decreased towards harvest stages. Application of coirpith recorded higher LAI, followed by KCl coliar spray during both the seasons.

Relative leaf water content

In general relative leaf water content (RLWC) decreased from flowering to pod-maturation stage. Higher values of RLWC were recorded in the monsoon than in summer at all the stages of crop growth. Irrigation scheduling at 0.60 IW : CPE ratio recorded higher values of RLWC, followed by 0.40 IW : CPE ratio (Table 2). Regarding method of irrigation, all furrow method recorded higher RLWC, followed by double-row furrow than alternate furrow irrigation. This might be attributed to frequent supply and higher amount of water to soil that resulted in increased uptake of water. Among the management practices, coirpith application maintained higher RLWC, followed by KCl. Potassium considered to be a better osmoticum for stomatal regulation and for the maintainance of better internal water balance in tissues.

Canopy temperature

Canopy temperature during flowering and pod-maturation stages was lower in the monsoon than in the summer. Irrigation scheduling at 0.60 IW : CPE ratio recorded lower canopy temperature compared to 0.40 IW : CPE ratio (Table 2). The increased uptake of water and higher tissue turgidity reduced the canopy temperature. Followed by double-row furrow irrigation. Alternate furrow irrigation recorded higher temperature. All the management practices, reduced the canopy temperature. The KCl spray resulted in reduced rate of transpiration and increased the internal water balance, thereby cooling the canopy. Lugg and Sinclair (1977) reported that potassium functions as a better osmoticum for stomatal regulation and retained good tissue water balance.

Transpiration rate

The higher transpiration rate was recorded under 0.60 IW : CPE ratio (I_2) and 0.40 IW : CPE ratio (I_1) (Table 3). Similar results were obtained by Sharma and Dixit (1988) in soybean and Selvaraju (1990) in maize. Higher transpiration rate was noticed during summer than monsoon. This might be attributed to lower relative humidity and higher day temperature. The transpiration rate was higher at flowering and slightly decreased at pod-maturation stage. The results indicated that the transpiration rate was significantly influenced by irrigation methods. All furrow irrigation method recorded a lower canopy temperature.

Among the management practices, coirpith application recorded higher transpiration rate than other treatments during both the stages. This might be due to moisture retention and slow-releasing ability of coirpith.

Stomatal diffusive resistance

The stomatal diffusive resistance was lower under higher moisture regime (I_2) and higher under 0.40 IW : CPE ratio (Table 3). This might be due to reduction in stomatal apertures which could resist the diffusion of water vapour out of the leaf. These findings

Table 2. Effect of irrigation levels, methods and management practices on relative leaf water content (%) and canopy temperature (°C) in soybean

Treatment	Relative leaf (%) water content				Canopy temperature (°C)			
	Flowering		Pod formation		Flowering		Pod formation	
	Summer	Monsoon	Summer	Monsoon	Summer	Monsoon	Summer	Monsoon
Irrigation								
I_1, 0.40 IW : CPE ratio	81.22	82.10	81.44	81.50	36.20	34.30	36.70	34.90
I_2, 0.60 IW : CPE ratio	84.53	85.28	83.36	84.20	35.20	33.20	35.80	33.80
CD (P = 0.05)	1.32	2.54	1.25	2.15	0.53	0.21	0.16	0.20
Method of irrigation								
M_1, all furrow method	83.88	84.64	83.51	83.83	35.20	33.80	35.24	34.26
M_2, alternate furrow	82.96	83.75	81.45	83.17	36.44	34.60	36.92	35.13
M_3, paired row or double row furrow	83.54	84.15	82.92	83.23	35.02	34.24	36.54	34.18
CD (P = 0.05)	0.24	0.34	0.26	0.35	0.33	0.24	0.13	0.13
Management practice								
A_0, Control	82.21	82.38	82.06	83.44	36.86	35.83	36.88	34.90
A_1, Coirpith application @ 12.5 tonnes/ha	83.61	84.49	83.26	84.27	36.18	35.12	36.24	34.30
A_2, Kaolin 3% foliar spray	83.28	83.92	83.12	83.72	36.52	35.64	36.64	34.76
A_3, KCl 0.5% spray	83.45	84.22	83.24	84.03	36.46	35.60	36.58	34.64
CD (P = 0.05)	0.11	0.14	0.07	0.06	0.23	0.20	0.11	0.11

Table 3. Effect of irrigation levels, methods and management practices on stomatal diffusive resistance (SDR) and transpiration rate (TR)

Treatment	SDR (S/cm)				TR (g $H_2O/cm^2/g$)			
	Flowering		Pod formation		Flowering		Pod formation	
	Summer	Monsoon	Summer	Monsoon	Summer	Monsoon	Summer	Monsoon
Irrigation								
I_1, 0.40 IW : CPE ratio	1.51	1.78	2.35	2.65	12.26	11.25	11.73	11.02
I_2, 0.60 IW : CPE ratio	1.26	1.52	2.13	2.32	13.22	12.48	12.85	12.98
CD (P = 0.05)	0.15	0.06	0.10	0.21	0.67	0.46	0.37	0.49
Method of irrigation								
M_1, all furrow method	1.24	1.42	2.16	2.30	13.16	12.32	12.73	12.40
M_2, alternate furrow	1.45	1.72	2.37	2.52	12.66	11.93	12.27	12.42
M_3, paired row or double row furrow	1.36	1.54	2.20	2.46	12.86	12.16	12.53	12.48
CD (P = 0.05)	0.04	0.07	0.04	0.04	0.08	0.08	0.06	0.13
Management practice								
A_0, Control	1.28	1.46	2.08	2.28	12.68	12.25	12.60	12.43
A_1, Coirpith application @ 12.5 tonnes/ha	1.31	1.53	2.12	2.35	12.72	12.29	12.63	12.48
A_2, Kaolin 3% foliar spray	1.30	1.60	2.18	2.40	12.36	11.63	11.92	12.16
A_3, KCI 0.5% spray	1.42	1.72	2.26	2.47	12.24	11.58	11.86	12.10
CD (P = 0.05)	0.02	0.06	0.04	0.04	0.23	0.10	0.25	0.14

confirm the results of Garside *et al.* (1992) in soybean.

Alternative furrow irrigation recorded a higher stomatal diffusive resistance to considerable extent. The KCl recorded SDR, followed by Kaolin.

Seed yield

The crop received a rainfall of 1,999 and 133 mm in the monsoon and summer respectively (Table 1). The monsoon crop recorded higher seed yield than summer crop. Irrigation scheduling at 0.60 IW : CPE recorded higher seed yield than 0.40 IW : CPE ratio. All furrow method recorded higher seed yield, followed by double-row furrow method. The higher seed yield was recorded due to maintenance of plant water relations favouring yield components. Management practices significantly influenced the seed yield. Coirpith application recorded higher seed yield, followed by KCl foliar spray.

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