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Influence of irrigation on water use in soybean (*Glycine max* L. Merrill)

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Abstract : Field experiments conducted during summer and *kharif* seasons of 1996 and 1997 revealed that the seasonal water use, rate of water use and consumptive use (CU) were higher with soybean raised during summer rather than those in *Kharif* and also with water use factor 0.90 IW/CPE ratio plus composted coirpith (CCP) application @ 12.5 t.ha^{-1}. The soil moisture content and extraction were higher in 0.90 IW/CPE ratio with the application of CCP under short term moisture condition (0.50 IW/CPE ratio). The soil moisture extraction (SME) pattern was almost uniform throughout the soil profile. But in adequate moisture supply (0.90 IW/CPE ratio) the SME was more from top 0-15 cm layer. Higher irrigation regime (0.90 IW/CPE ratio) with the application of CCP enhanced the grain yield. Under short-term moisture stress condition, the yield could be sustained with the application of CCP.

Key Words : Soybean, Water use factor, Composted coir pith, Seasonal water use, Consumptive use, Soil moisture extraction, Seed yield.

Introduction

Water being a limiting resource, it is essential for efficient use of irrigation water for higher returns. Though the water requirement could be optimised, the success depends on the efficient utilization of water received through irrigation during the crop growth. For ensuring efficient utilization of water, composted coir pith comes handy as it increases water holding capacity and brings changes in drainage, soil conservation and moisture conservation properties (Ravindranath, 1991). In the light of the above, it was felt imperative to take up study in soybean (*Glycine max* L. Merrill), for optimising irrigation water requirement and evaluating the influence of composted coir pith.

Materials and Methods

Field experiments were conducted during summer and *kharif* seasons of 1996 and 1997 respectively at Agricultural Research Station, Aliyarnagar, Tamil Nadu Agricultural University to investigate the response of soybean to irrigation and composted coirpith (CCP). The soil of the experimental field is well-drained sandy clay loam with pH 7.4, EC 0.40 dsm^{-1}, low in available N (216 kg ha^{-1}), medium in available P (17.6 kg ha^{-1}), high in available K (281 kg ha^{-1}). The organic carbon content was 0.33, while it was 23.15 per cent for field capacity and 12.50 per cent for permanent wilting point. The treatments replicated thrice were laid out in split plot design. The treatment consisted of three levels of water use factors (IW/CPE ratio) *viz.* 0.50 (I_1), 0.70 (I_2) and 0.90 (I_3) and two levels of CCP *viz.* without CCP (C_1) and with CCP (C_2) at the rate of 12.5 t ha^{-1}.

In this water use studies, seasonal water use, rate of water use, consumpive water use, soil moisture content and soil moisture extraction pattern were studied. The seasonal water use was computed by Di + ER, where Di was applied water depth for ith irrigation (mm), n was number of irrigation and ER was effective rainfall (mm). The seasonal water was divided by the duration of the crop to arrive water use rate (mm day^{-1}). In computing CU, soil moisture content was estimated gravimetrically before and 48 hours after each irrigation. The difference between the moisture contents was taken as consumptive use, in which effective rainfall was also taken into account following the procedure suggested by Misra and Ahmed (1993). Effective rainfall was computed using the balance sheet method (Gupta *et al.* 1972). Soil samples were drawn from 0-15, 15-30 and 30-45 cm depths before and after 48 hours of each irrigation and available soil moisture content was determined gravimetrically on ove

Table 1. Seasonal and rate of water use by soybean

Irrigation levels (IW/CPE)	Irrigation water applied during the season (mm)	Seasonal water use (mm)	Rate of water use (mm day^{-1})
Summer			
I_1 - 0.50	330	393.3	4.37
I_2 - 0.70	390	442.8	4.92
I_3 - 0.90	450	497.1	5.52
Kharif			
I_1 - 0.50	210	33.6	3.71
I_2 - 0.70	270	371.3	4.13
I_3 - 0.90	330	414.4	4.60

Consumptive use (mm)

Treatment	Summer			Kharif		
	C_1	C_2	Mean	C_1	C_2	Mean
I_1	292.0	323.7	307.9	238.	255.7	246.9
I_2	323.8	352.1	338.0	257.6	272.2	264.9
I_3	347.8	371.3	359.5	272.9	283.2	278.1
Mean	321.2	349.0	335.1	256.2	270.4	263.3

Data statistically not analysed.

Table 2. Mean soil moisture content (per cent) estimated before each irrigation

Summer	C_1 Depth (cm)				C_2 Depth (cm)				Mean
	0-15	15-30	30-45	Mean	0-15	15-30	30-45	Mean	
I_1	12.5	14.8	18.0	15.1	14.2	15.5	18.4	16.0	15.6
I_2	13.7	15.6	19.9	16.4	15.1	16.1	20.2	17.1	16.8
I_3	13.9	15.9	20.6	16.8	15.2	16.3	20.9	17.5	17.2
Mean	13.4	15.4	19.5		14.8	16.0	19.8		
Mean		16.1				16.9			

Kharif	C_1 Depth (cm)				C_2 Depth (cm)				Mean
	0-15	15-30	30-45	Mean	0-15	15-30	30-45	Mean	
I_1	12.9	15.1	18.8	15.6	15.4	16.7	19.9	17.3	16.5
I_2	14.9	17.5	21.5	18.0	17.0	18.9	22.7	19.5	18.8
I_3	15.3	17.7	22.9	18.6	17.2	19.1	23.1	19.7	19.2
Mean	14.4	16.8	21.0	-	16.5	18.2	21.9	-	-
Mean		17.4				18.8			

Data statistically not analysed.

Table 3. Soil moisture extraction pattern (per cent)

Summer

Treatments	C_1 Depth (cm)			C_2 Depth (cm)		
	0-15	15-30	30-45	0-15	15-30	30-45
I_1	36.5	32.7	30.8	42.5	37.3	20.2
I_2	41.0	36.2	22.8	46.3	40.4	13.3
I_3	43.0	38.1	18.6	48.5	41.5	10.0

Kharif

Treatments	C_1 Depth (cm)			C_2 Depth (cm)		
	0-15	15-30	30-45	0-15	15-30	30-45
I_1	37.8	33.5	28.7	46.4	37.1	16.5
I_2	41.2	38.9	19.9	48.1	41.0	10.9
I_3	42.8	39.5	17.7	49.3	41.6	9.1

Data statistically not analysed.

dry basis and from this, fraction of moisture depleted from each soil layer was calculated and soil moisture extraction pattern was arrived at and expressed in per cent.

Results and Discussion

Seasonal water use (SWU)

Seasonal water use was more during summer than the one during *kharif* irrespective of water use factors owing to higher evaporative demand (551.9 and 478.3 mm during summer 1996 and 97 respectively) and lesser rainfall (120.2 and 41.5 mm during summer 1996 and 97 respectively). The SWU increased from 393.3 to 497.1 and 333.6 to 414.4 mm for the water use factor from I_1 to I_3 during summer and *kharif* respectively (Table 1). This was due to subsequent increase in irrigation regime from 0.50 to 0.90 IW/CPE ratio which added 103.8 to 80.8 mm of more water to the soil in 0.90 IW/CPE ratio over 0.50 IW/CPE ratio of summer and *kharif* respectively.

Rate of water use

The rate of water use was higher in the crop, which received frequent irrigation (0.90 IW/CPE) in both the seasons (Table 1). Under non-limiting conditions of water supply, evapo-transpiration was largely governed by the dynamics of microclimate rather than by plant and soil factors (Ramesh and Gopalswamy, 1992).

Consumptive water use (CU)

The CU was found to be higher in summer than that in *kharif*. Every additional irrigation due to increased water use factor from 0.50 to 0.70 and then to 0.90 IW/CPE ratio increased the CU by 9.8 and 6.4 per cent in summer and by 7.3 and 5.0 per cent in *kharif* (Table 1). The contribution of seasonal water use to CU was higher in summer (78.3 to 72.3 per cent) than the one in *kharif* (74.0 to 67.1 per cent). When the weather parameters remained the same, the loss of water through evapo-transpiration became function of soil moisture supply (Hoogenboom *et al.* 1987).

Application of CCP @ 12.5 t ha^{-1} (C_2) during summer in the moderate irrigation regime (0.70 IW/CPE) increased the CU by 4.3 mm when compared to the CU in the higher irrigation regime (0.90 IW/CPE) wherein no CCP (C_1)

was applied. It was due to the fact that application of CCP helped in the retention of more moisture due to its highly carbonaceous nature (Mayalagu *et al.* 1983).

Soil moisture content (SMC)

The SMC estimated before each irrigation increased with the depth of the soil profile, frequency of irrigation and addition of CCP, irrespective of the season. The SMC was higher in water use factor 0.90 IW/CPE ratio (17.2 and 19.2 per cent during summer and *kharif* respectively) because of narrower irrigation frequency. It was also higher in lower soil profile (30-45 cm) 19.7 and 21.5 per cent during summer and *kharif* respectively (Table 2).

Application of CCP increased the SMC by five per cent in summer and eight per cent in *kharif* against control. Irrespective of water use factors, the difference in the SMC in the upper soil layer (0-15 cm) was higehr (1.7 to 1.3 and 2.5 to 1.9 per cent during summer and *kharif* respectively) between CCP application and non-application and the difference in the SMC between these two was less pronounced in the lower layers. Since most of the CCP (higher moisture holding capacity) incorporated was retained in the upper soil profile (0-15 cm) which held more moisture for longer period (Ramaswami and Sree Ramalu, 1983), the difference in the SMC was higher in the CCP application than that in the non-application (Table 2).

Moisture extraction pattern (MEP)

The MEP under all irrigation levels showed that most of the moisture was extracted from 0-30 cm depth, with top 15 cm layer contributing the most when minimum number of irrigation was given (0.50 IW/CPE) (Table 3; Fig. 1). Moisture contribution from lower soil profile (30-45 cm) was higher in less irrigation water applied treatment (0.50 IW/CPE (25.5 and 22.6 per cent during summer and *kharif* respectively). It was due to high rate of depletion of moisture from the upper layers and thus inducing the crop to extend the root system more profusely to deeper layers to extract more moisture. The relative contribution of moisture in the upper layer for extraction was higher with CCP application (45.8 and 47.9 per cent during summer and *kharif* respectively). Since the incorporation of CCP was mostly in the top 0-15 cm layer, the SMC was higher in that layer and more over the rate of water take up was proportional to the root activity at a particular depth (Singh and Singh, 1993).

Seed yield

The seed yield was higher during *kharif* than that during summer. Irrespective of seasons, water use factors and CCP levels established marked influence on the seed yield. Higher moisture regime with 0.90 IW/CPE ratio registered higher seed yield by 30.2 and 7.4 per cent in summer and 17.0 and 5.4 per cent in *kharif* than 0.50 and 0.70 IW/CPE ratios (Table 4). Adequate quantity of irrigation water (450 and

Table 4. Seed yield (kg ha^{-1}) of soybean

Treatment	Summer			*Kharif*		
	C_1	C_2	Mean	C_1	C_2	Mean
I_1	1064	1227	1145	1377	1499	1438
I_2	1321	1454	1388	1548	1644	1596
I_3	1437	1545	1491	1648	1716	1682
Mean	1274	1409		1524	1620	
CD (P=0.05)						
I	44	28				
C	36	23				
I x C	63	40				

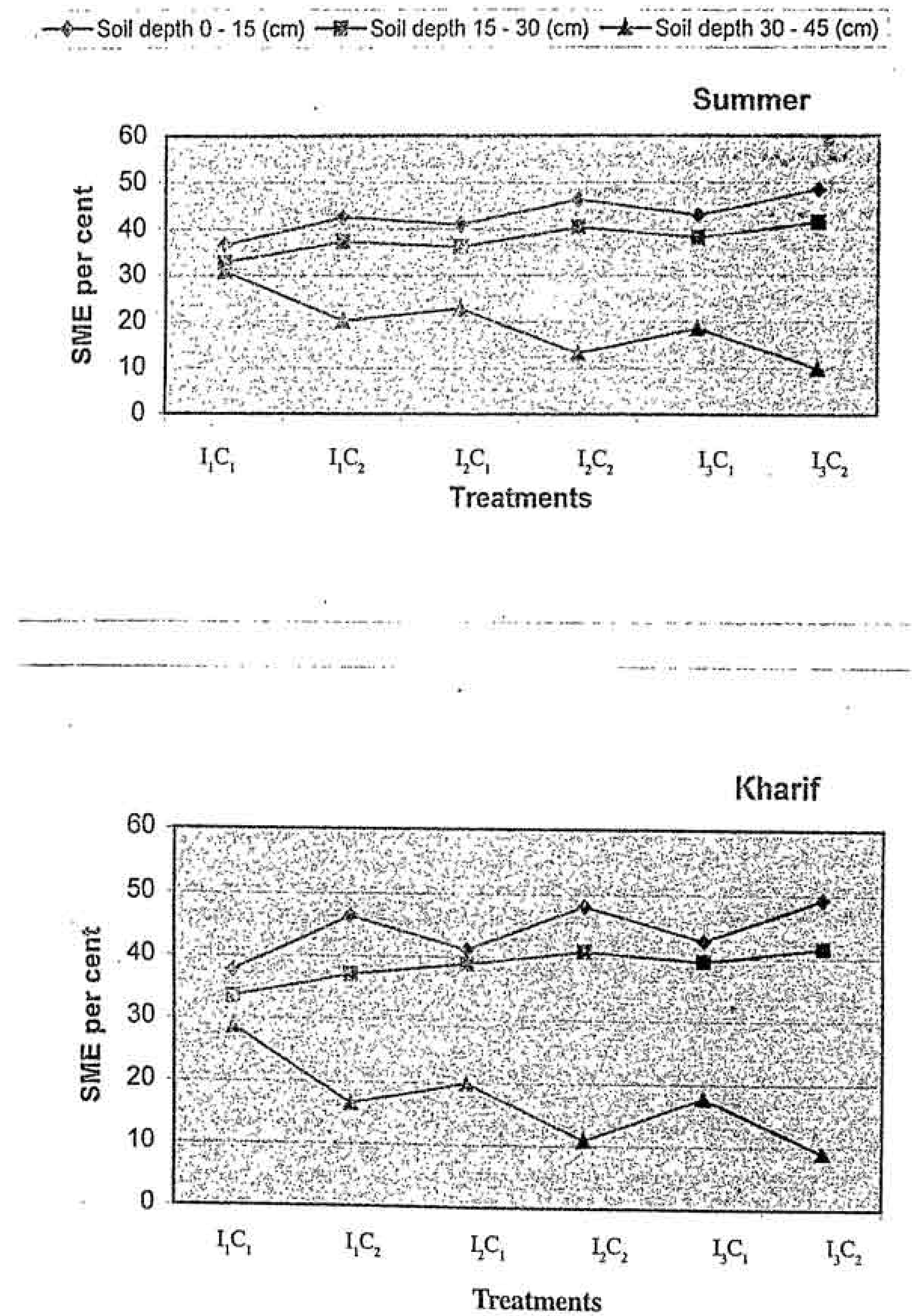

Fig.1 Soil Moisture Extraction pattern (per cent)

330 mm during summer and *kharif* respectively) with optimum consumptive use of water (359.5 and 278.1 mm during summer and *kharif* respectively) (Table 1) favoured in obtaining higher seed yield. The yield increase was significant from the lower moisture regime of 0.50 to 0.70 beyond which it was not appreciable.

Application of CCP at the rate of 12.5 t ha^{-1} helped to accentuate the yield appreciably to 10.6 and 6.3 per cent against non-application of CCP during summer and *kharif* respectively. The rate of increase in yield by the addition of CCP was more during summer (135 kg ha^{-1}) than that during *kharif* (96 kg ha^{-1}). The CCP being an organic matter, increased the buoyancy of soil and improved the soil structure and thus providing optimum soil environment. Moreover, the higher water holding capacity of CCP, supplied moisture in a sustained manner and alleviated the moisture stress condition. These factors cumulatively increased the growth habit and yield attributes resulting in higher soybean seed yield.

Another distinct feature observed was that even under lower level of irrigation (I_1), with the application of CCP, the yield increased was nearly 15.3 and 8.9 per cent against without application of CCP, indicating that the increase in seed yield could be obtained by the application of CCP at times of short-term moisture stress.

The foregoing discussion revealed that SWU, rate of water use and CU were higher during summer than those during *kharif*. The water use by soybean increased with the increase in frequency of irrigation and application of CCP. The extraction of moisture from the lower depth (30-45 cm) was noticed under limited water supply and without incorporation of CCP. The SMC increased with the depth in soil profile and frequency of irrigation. The effect of incorporation of CCP on the soil moisture content was more pronounced. Higher irrigation regime (0.90 IW/CPE ratio) with the application of CCP enhanced the grain yield. Under short-term moisture stress condition, the yield could be sustained with the application of CCP.

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