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Influence of integrated management of irrigation, composted coirpith and nutrients on the relative leaf water content, transpiration rate and yield of soybean (*Glycine max* L. Merrill)

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Abstract: Field experimetns were conducted during summer (February-May) and *kharif* (June-September) seasons of 1996 and 1997 at Agricultural Research Station, Aliyarnagar, Tamil Nadu Agricultural University, India to study the influence of integrated management of irrigation, composted coirpith and nutrient on the physiological parameters and yield of soybean. Results revealed that frequent irrigation (0.90 IW/CPE) with composted coirpith and split application of N,P and K with nutrient mixture spray maintained higher relative leaf water content and transpiration rate. This treatment has also significantly increased the seed yield of soybean.

Key words : Soybean, Irrigation, Composted coirpith, Nutrients, Relative leaf water content, Transpiration rate, Yield.

Introduction

Soybean has an important role to play in meeting the expanding demands for protein, edible oil and calories. Though many factors contribute for increasing the yield potential of soybean, water is considered to be the vital input because crop responses to all other inputs chiefly depend on the availability of required quantity of water at right time. Li *et al.* (1992) reported that the rate of photo synthesis increased with increasing water supply upto 1.80 kg per plant and then slightly decreased with higher rate of water supply. It is assessed that in India, 7.5 million tonnes of coirpith (the coconut coir rope factory waste) is produced annually (Kamaraj, 1994). Application of coirpith to soil, besides increasing the water holding capacity, brings about favourable changes in drainage, mulching, crop rooting, soil reconditioning and seed germination (Ravindranath, 1991). There is dearth of information on the utility of composted coirpith for effective utilization of applied water in soybean. In soybean, though many attempts have been made to quantify the nutrient requirement, studies on the effect of time of application of nutrients and foliar nutrition on physiological parameters of soybean and yield are limited. In view of the above facts, the present stud was undertaken to study the effect of differer irrigation regimes, composted coirpith, time o application of N,P,K and use of nutrient mixtur spray on the relative leaf water content, transpiratio rate and yield of soybean.

Materials and Methods

Field experiments were conducted in soybea during summer (February-May) and *kharif* (June September) seasons of 1996 and 1997 a Agricultural Research Station, Aliyarnagar, Tami Nadu, India geographically situated at 10°39'N latitude and 77°0' E longitude at an altitud of 260m above mean sea level.

The soil of the experimental field wa well drained sandy clay loam with a pH o 7.4, EC of 0.4 dSm^{-1}, organic carbon conten of 0.33 per cent, low available N (216 kg ha^{-1}), medium available P (17.6 kg ha^{-1}) and high available K (281 kg ha^{-1}). The bulk density of the soil was 1.41 mg m^{-3} with a field capacity of 23.15 per cent and permanent wilting poin of 12.5 per cent. The pH of the irrigatior water was 7.9, EC 0.6 dSm^{-1} with a sodium adsorption ratio of 2.9.

Table 1. Relative leaf water content (per cent) a pod formation stage

Treatment	Summer season						*Kharif* season					
	I_1	I_2	I_3	C_1	C_2	Mean	I_1	I_2	I_3	C_1	C_2	Mean
F_1	76.78	80.33	82.19	78.88	80.65	79.77	78.22	82.18	83.40	80.06	82.47	81.26
F_2	77.42	81.46	82.75	79.76	81.32	80.54	79.06	83.10	84.29	80.93	83.36	82.15
F_3	77.70	81.70	83.00	79.90	81.70	80.80	79.21	83.27	84.44	81.09	83.53	82.31
F_4	78.85	82.48	83.61	80.60	82.35	81.48	79.94	84.12	85.33	81.85	84.40	83.13
C_1	76.46	80.47	82.44			79.79	77.62	81.74	83.60			80.98
C_2	78.67	82.52	83.34			81.51	80.89	84.60	85.13			83.44
Mean	77.56	81.49	82.89				79.11	83.17	84.36			
						CD (P=0.05)						CD (P=0.05)
I						1.59						1.63
C						1.27						1.33
I x C						2.48						2.31
F						NS						NS
I at F						4.55						4.60
F at I						NS						NS
C at F						NS						NS
F at C						NS						NS

The experiment was laid out in split plot design with three replications. The treatment details are :

Main plot treatments

A. Water use factors

- I_1 - Irrigation at 0.50 IW/CPE ratio [ratio of irrigation water depth (IW) and cumulative pan evaporation (CPE)]
- I_2 - Irrigation at 0.70 IW/CPE ratio
- I_3 - Irrigation at 0.90 IW/CPE ratio

B. Composted coirpith (CCP) levels

- C_1 - Control (without com posted coirpith)
- C_2 - Composted coirpith @ 12.5 t ha^{-1}.

Sub-plot treatments

Fertilizer management practices

- F_1 - Recommended dose of NPK - All basal
- F_2 - Recommended dose of NPK in two splits (50% as basal + 50% as top dressing at 30 days after sowing (DAS))
- F_3 - F_1+Nutrient mixture spray (2% concentration) twice at 30 and 45 DAS.
- F_4 - F_2+Nutrient mixture spray (2% concentration) twice at 30 and 45 DAS.

The fertilizer schedule recommended for soybean in Tamil Nadu, 20:80:40 kg NPK ha^{-1} was adopted. The nutrient mixture consisted of Di-Ammonium Phosphate (1.0%), MOP (0.50%) and micronutrient mixture (0.5%), totaling to 2 per cent concentration.

Table 2. Transpiration rate (µg cm^{-2} s^{-1}) at pod formation stage

Treatment	Summer season						*Kharif* season					
	I_1	I_2	I_3	C_1	C_2	Mean	I_1	I_2	I_3	C_1	C_2	Mean
F_1	9.87	11.11	11.86	10.72	11.17	10.95	6.72	7.84	8.76	7.49	8.06	7.77
F_2	9.99	11.21	11.94	10.82	11.28	11.05	6.81	7.96	8.88	7.60	8.17	7.88
F_3	10.05	11.28	12.01	10.88	11.34	11.11	6.88	8.04	8.95	7.67	8.24	7.96
F_4	10.17	11.40	12.09	10.99	11.44	11.22	6.97	8.16	9.07	7.78	8.35	8.07
C_1	9.72	11.01	11.83			10.85	6.55	7.72	8.64			7.64
C_2	10.32	11.48	12.12			11.30	7.14	8.28	9.19			8.20
Mean	10.02	11.25	11.97				6.84	8.00	8.91			
						CD (P=0.05)						CD (P=0.05)
I						0.28						0.21
C						0.21						0.18
I x C						0.41						0.30
F						NS						NS
I at F						0.59						0.50
F at I						NS						NS
C at F						0.41						0.41
F at C						NS						NS

Iron (4.0%), zinc (3.0%), manganese (2.0%) and copper (0.1%) were the micronutrients in the micronutrients mixture. The nutrient mixture spray solution was prepared (at the rate of 500 litres ha^{-1}) a day before, and the supernatant solution alone was used for spraying with a hand operated knapsack sprayer.

The experimental field was ploughed and harrowed and after levelling, flat beds were formed. A gross plot size of 5.0 m x 4.2 m and a net plot size of 4.8 m x 3.6 m was adopted. Composted coirpith produced from raw coirpith by adopting the methodology of Nagarajan *et al.* (1987) was incorporated basally in the respective plots after forming flat beds but before levelling of the field. The composted coirpith had a pH of 7.10, EC of 0.36 dSm^{-1}, C:N ratio of 25:1 and N,P and K content of 0.99, 0.07 and 1.09 per cent respectively. The soybean seeds (CO 1) were dibbled in lines adopting a row spacing of 30 cm with a plant to plant spacing of 5 cm.

Irrigation was given to all the plots immediately before sowing and the next irrigation was given on the third day. Subsequent irrigations were given as per the treatments. For scheduling irrigation based on climatological approach evaporation rate from USWB class A open pan evaporimeter was recorded daily. A common depth of irrigation *i.e.* 60 mm was adopted. Thus, irrigation was given to 0.5 (I_1), 0.70 (I_2) and 0.90 (I_3) IW/CPE ratios, whenever cumulative pan evaporation reached the lev f 120, 85.7 and 66.7 mm espectively. Parshall flume of .5 cm throat width was used for neasuring the volume of water efore letting into each plot.

The relative leaf water content RLWC) of leaves was estimated ccording to the method suggested y Slatyer and Barrs (1965).

$$\text{RLWC} = \frac{\text{Fresh weight} + \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}}$$

The RLWC was estimated t pod formation stage before rigation. The transpiration rate vas recorded between 12.00 and 4.00 hours at pod formation stage rom the fully expanded leaf before rrigation using LI-1600 steady state orometer. Soybean seed yield from he net plot area was recorded t 12 per cent moisture and computed o kg ha^{-1}.

Results and Discussion

Relative leaf water content (RLWC)

The RLWC was significantly nfluenced by water use factors nd composted coirpith (CCP) levels nd not by fertilizer management ractices in both the seasons (Table 1). The crop which received frequent rrigations (0.90 IW/CPE) recorded igher percentage of RLWC (82.9 nd 84.4 per cent during summer nd *kharif* respectively) but was omparable with 0.70 IW/CPE (81.5 nd 83.2 per cent during summer nd *kharif* respectively). It was ignificantly less under irrigation vith 0.50 IW/CPE (77.6 and 79.1 er cent during summer and *kharif* espectively). The values recorded

Table 3. Seed yield (kg ha^{-1}) of soybean

Treatment	Summer season						*Kharif* season					
	I_1	I_2	I_3	C_1	C_2	Mean	I_1	I_2	I_3	C_1	C_2	Mean
F_1	1060	1252	1325	1155	1269	1212	1337	1435	1494	1386	1458	1422
F_2	1129	1364	1462	1253	1384	1318	1410	1570	1651	1501	1592	1547
F_3	1153	1396	1498	1281	1416	1349	1447	1606	1690	1532	1629	1581
F_4	1241	1539	1680	1408	1565	1486	1548	1774	1893	1678	1799	1738
C_1	1064	1321	1437	-	-	1274	1377	1548	1648	-	-	1524
C_2	1227	1454	1545	-	-	1409	1499	1644	1716	-	-	1620
Mean	1145	1388	1491	-	-	-	1438	1596	1682	-	-	-
	CD	CD				(P=0.05)						(P=0.05)
I						44						28
C						36						23
I x C						63						40
F						49						58
I at F						86						91
F at I						85						100
C at F						70						74
F at C						70						82

Table 4. Water use studies

Irrigation levels (IW/CPE)	Irrigation water applied (mm)	Effective rainfall (mm)	Seasonal water use (mm)	Rate of water use (mm day^{-1})
Summer				
I_1 - 0.50	330	63.3	393.3	4.37
I_2 - 0.70	390	52.8	442.8	4.92
I_3 - 0.90	450	47.1	497.1	5.52
Kharif				
I_1 - 0.50	210	123.6	333.6	3.71
I_2 - 0.70	270	101.3	371.3	4.13
I_3 - 0.90	330	84.3	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	238.1	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

during both the seasons showed that application of CCP significantly increased the RLWC compared to that of non-application of CCP. The favourable micro-climate and physical condition of the soil coupled with the availability of higher moisture due to the incorporation of CCP increased the RLWC (Rajagopal and Palchamy, 1989). With regard to interactions, the water use factor of 0.90 was significantly superior to 0.50 but as comparable to 0.70 at both the CCP levels, in both the seasons. In all the fertilizer management practices, the water use factor 0.90 was significantly superior to 0.50. But, it is comparable to 0.70 irrespective of seasons. The RLWC was significantly higher with the application of CCP than that without application of CCP at the water use factors of 0.50 and 0.70. But, it was comparable with each other at higher water use factor of 0.90. However, fertilizer management practices did not have any significant influence on CCP applications. Similar trend was observed in both the seasons. The interactions of fertilizer management practices with both water use factors and CCP levels did not show any significant variations on RLWC.

Transpiration rate

The data on transpiration rate reveal that values recorded with water use factor 0.90 were significantly higher (11.97 and 8.91 µg $cm^{-2}s^{-1}$ during summer and *kharif* respectively) than the one with 0.70 (11.25 and 8.00 µg $cm^{-2}s^{-1}$ during summer and *kharif* respectively), which was significantly superior to 0.50 (Table 2). The rate of transpiration depended on the energy available to evaporate water, the difference in water vapour between leaves and air and the resistance in the water vapour pathway (Kaufman, 1981). The reduction in transpiration rates in short-term moisture stress plants (0.50 IW/CPE) was observed through the resultant loss of soil moisture availability and subsequent increase in leaf temperature (Bardford and Hsiao 1982), which had significant negative association with transpiration rate. The CCP levels exhibited significant influence on transpiration rate irrespective of seasons. The CCP application recorded higher values of 11.30 and 8.20 µg $cm^{-2}s^{-1}$ during summer and *kharif* respectively than non-application of CCP (10.85 and 7.6 µg $cm^{-2}s^{-1}$). Application of CCP helped in th etention of higher moisture in the soil which esulted in higher transpiration rate (Ravi Barathi, 994). Fertilizer management practices did not how any significant variation on transpiration ate. The transpiration rates recorded with all he three water use factors differed significantly vith each other. The irrigation schedule of .90 IW/CPE recorded the highest transpiration ate at both the CCP levels and fertilizer management ractices during both the seasons. Application f CCP recorded significantly higher transpiration ate than the non-application of CCP at all he three water use factors during both the easons. Similarly, the CCP levels significantly ncreased the transpiration rate at the fertilizer nanagement practices of F_1 and F_3 only during ummer, but at all fertilizer management practices uring *kharif*. The perceptible interactions of ater use factors and CCP levels and water se factors at all fertilizer management practices vere due to higher soil moisture status, and esultant additive effects. Fertilizer management ractices did not have percetible influence on ranspiration rate at all levels of water use actors and CCP levels.

Soybean seed yield

Soybean responds very well to the crop rowth season. *Kharif* was found to be more deal for soybean for getting higher yield than ummer (Table 3). The yield increase of 17.2 per cent in *kharif* as against summer was due o well-distributed adequate quantity of rainfall 180.3 mm) in 19 rainy days coupled with optimum evaporative demand (447.0 mm) with conducive temperature (30.4°C). The accelerated rate of growth and reproductive organs due o the above factors resulted in higher yield. Adequate quantity of irrigation was 450 and 330 mm during summer and *kharif* respectively with optimum consumptive use of water (359.5 and 278.1mm during summer and *kharif* respectively) (Table 3) under 0.90 IW/CPE ratio resulted in significantly higher soybean grain yield.

Frequent irrigations induced better physiological functions like increased transpiration rae with higher RLWC which led to increased seed yield. Increased soil water deficit resulted in slower growth, declined RLWC (Blum, 1974) and significant reduction in the rate of photosynthesis by the reduced leaf production rate and size of leaves (Sivakumar and Shaw, 1978) which led to lower accumulation and translocation of photosynthates and subsequent ovule abortion reduced the number of pods per plant (Muchow, 1985) and ultimately the seed yield.

The effect of CCP application was more pronounced under insufficient moisture availability condition. This was well marked in summer. The CCP being an organic matter, increased the buoyancy of soil and improved soil structure and thus providing optimum soil environment. Moreover, the higher water holding capacity of CCP, supplied moisture in a sustained manner and alleviated moisture stress condition coupled with addition of plant nutrients to the soil. These facts cumulatively increased the growth habit and yield attributes resulting in higher soybean seed yield (Ravi Barathi, 1994). Another distinct feature observed as mentioned earlier was that even under low level of irrigation (I_1) with the application of CCP, the yield increase was nearly 15.3 and 8.9 per cent against the treatment without application of CCP, indicating that seed yield increase could be obtained by the application of CCP at times of short-term moisture stress.

Split application of N, P and K with nutrient mixture spray primarily facilitated higher availability of plant nutrients throughout the crop growth period. The nutrients especially N promotes the synthesis of proteins, organic phosphorus compounds and carbohydrates and promoted better vegetative growth. P helps in increasing the test weight and K played an important role in water uptake and the regulation of its loss through stomatal apertures, improved water relations in plants and thus sustained the grain yield. Micronutrients regulated various physiological (metabolic) activities and helped cumulatively in increasing the seed yield of soybean. By better manipulation of nutrients feeding in the very early stage i.e. from germination to active vegetative stage (0-30 DAS), the earlier growth was built up without wasting nutrients and the maximum vegetative stage (30 DAS) and peak flowering stage (45 DAS) were additionally supported by this nutrient supply through the combination of basal and foliar feedings. This led to the production of higher growth and yield characters and finally resulted in higher seed yield.

The beneficial contribution of individual factors *viz.* higher irrigation regime (0.90 IW/CPE), application of CCP and split application of recommended dose of N, P and K coupled with nutrient mixture spray had synergistic effect with each other and boosted the seed yield significantly in I_3C_2, I_3F_4 and C_2F_4 combinations.

Water use

Seasonal water use was more during summer than the one during *kharif* irrespective of water use factors. The quantity of effective rainfall decreased progressively as water use factor increased from 0.50 through 0.90(63.3 to 47.1 and 123.6 and 84.3 mm for summer and *kharif* respectively). The utilization of annual rainfall was more effective during summer (78.2 to 58.2 per cent) than that during *kharif* (68.5 to 46.8 per cent). The seasonal water use increased from 393.3 to 497.1 to 333.6 to 414.4 mm during summer and *kharif* respectively. This was due to subsequent increase in irrigation regime from 0.50 to 0.90 IW/CPE which added 103.8 and 80.8 mm of water to the soil in 0.90 IW/CPE during summer and *kharif* respectively.

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