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Productivity and water use efficiency of spring Soybean (*Glycine max)* as affected by levels of irrigation and sources of sulphur

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ABSTRACT

Field experiment was conducted at the alluvial zone of West Bengal, India during 2000 & 2001 to study the effect of different levels of irrigation and sources of sulphur on the productivity of soybean. Results revealed that seed yield (1.88 t/ha), Oil content (21.31%) were maximum when the crop was irrigated at 0.45 atmospheric tension and sulphur was applied @ 40kg S/ha in the form of gypsum. But the gypsum is more costly than single super phosphate. For that reason the net return (Rs. 11,894/ha) and return per rupee investment (1.93) were showed maximum value for the application of single super phosphate along with irrigation at 0.45 atmospheric tension. Scheduling of irrigation at 0.30 atmospheric tension increased the consumptive use of water but decreased the water use efficiency.

Key words : Productivity, soybean, irrigation, sulphur

Soybean contains 20 percent oil and 40 percent protein. Application of sulphur increased seed yield of soybean by 2.2 to 3.9 q/ha as well as 6.8 percent oil content (Yogendra *et al.* 1992). Sulphur is also required for containing amino acids like cystine, methionine and consequently it promotes to synthesis of protein. On the other hand this crop could successfully be introduced in intervening period of two main crops (between winter and monsoon season). Spring soybean is responsive to application of irrigation. For efficient utilization of irrigation water, it is necessary to find out the optimum soil moisture tension for irrigation the crop. The present investigation was, therefore, initiated to test the feasibility of sulphur sources and levels of irrigation on improving the quality and production of spring sown soybean (*Glycine max*).

MATERIALS AND METHODS

The field experiment was conducted during spring season of 2000 and 2001 at the University Farm situated at $22^0 56^/$ E longitude at an altitude of 9.75 m above mean sea level. The soil of the experimental plot was alluvial sandy loam in texture with pH 6.8 and organic carbon 0.613 percent. Total N, available P_2O_5, K_2O and sulpher (0.15 CaCl extractable) content of the soil were 0.063 percent, 36.21 kg/ha, 162.40kg/ha and 6.22 ppm, respectively. The experiment was carried out in split plot design with four main plot treatments (irrigation at 0.30, 0.45, 0.60 and 0.75 atmospheric tensions) and five subplot treatments (Sources of sulphur- Elemental sulphur, Pyrite, Gypsum, Single super phosphate and No sulphur) replicated thrice. Uniform dose of nitrogen @ 20kg/ha (applied in the form of urea in S.S.P. treated plots and Diammonium phosphate in others plots) and phosphorus @ 60kg/P_2O_5/ha (in the form of DAP) and potassium @ 60kg/K_2O/ha (in the form of Potassium chloride) were applied before sowing along with different sources of sulphur @ 40kg S/ha. Seeds of Soybean, variety PK-327 were treated with Bready *rhizobium japonicum* @ 5 g/kg of seed before sowing. The treated seed were sown at a spacing of 30 X 10cm. At maturity seeds and stover collected were ground and digested in HNO_3: $HclO_4$ (5:1) mixture and analysed for sulphur content (Chesnin and Yien, 1951). The data on nitrogen content determined by Kjeldahl method were converted to protein by multiplying with 6.25. The consumptive use of water under different treatment was computed as per the procedure of Dastane (1972). The water use efficiency in Kg/ha/mm for a given treatment was calculated dividing the grain yield by respective total consumptive use for the crop period.

RESULTS AND DISCUSSION

Effect of levels of irrigation

Soybean responded significantly to the level of irrigation. Seed (1.61 t/ha) and stover (1.93 t/ha) yields were recorded maximum when the crop received irrigation at 0.45 atmospheric tension (Table-1). Irrigation at 0.75 atmospheric

Table-1: Effect of different sources of sulphur on soybean under different levels of irrigation (Mean of 2000 and 2001).

Level of irrigation	Elemental sulphur	Pyrite	Gypsum	SSP	No sulphur	Mean		SEm±	CD (P=0.05)
Seed yield (t/ha)									
0.30atm	1.24	1.21	1.32	1.26	0.98	1.21	l(irrigation)	0.006	0.022
0.45atm	1.59	1.64	1.88	1.73	1.19	1.61	S (sulphur)	0.008	0.023
0.60atm	1.49	1.40	1.62	1.52	0.98	1.42	l X S	0.013	0.039
0.75atm	0.94	0.93	1.12	0.93	0.90	0.96			
Mean	1.32	1.30	1.49	1.36	1.40	-			
Stover yield (t/ha)									
0.30atm	2.06	2.01	2.17	2.10	1.67	2.00	l	0.004	0.014
0.45atm	2.01	1.96	2.11	1.96	1.61	1.93	S	0.005	0.015
0.60atm	1.95	1.94	2.08	1.95	1.62	1.91	l S	0.010	0.030
0.75atm	1.82	1.80	1.87	1.82	1.48	1.76			
Mean	1.96	1.93	2.05	1.96	1.60	-			
Oil content (%)									
0.30atm	19.43	19.85	20.48	19.86	18.70	19.66	l	0.12	0.43
0.45atm	20.06	20.73	21.31	20.59	18.73	20.18	S	0.09	0.26
0.60atm	19.55	19.99	20.89	20.15	18.66	19.85	l X S		NS
0.75atm	18.90	19.21	19.68	19.45	18.20	19.09			
Mean	19.48	19.82	20.59	20.01	18.57	-			
Protein content (%)									
0.30atm	34.24	34.18	35.74	34.11	32.05	34.06	l	0.04	0.014
0.45atm	34.55	34.46	35.88	34.44	32.16	34.30	S	0.05	0.16
0.60atm	34.31	34.21	35.50	34.21	32.10	34.06	l X S		NS
0.75atm	34.15	34.10	34.81	34.10	32.00	33.83			
Mean	34.32	34.24	35.48	34.21	32.07	-			
Sulphur content (%) in seed									
0.30atm	0.419	0.432	0.454	0.438	0.289	0.406	l	0.04	0.0013
0.45atm	0.420	0.464	0.481	0.471	0.296	0.426	S	0.005	0.0014
0.60atm	0.410	0.420	0.476	0.461	0.298	0.412	l X S	0.001	0.003
0.75atm	0.356	0.379	0.405	0.396	0.260	0.358			
Mean	0.400	0.423	0.454	0.441	0.284	-			
Net return (Rs/ha)									
0.30atm	6555	6511	3150	8220	5523	5992			
0.45atm	10173	10422	7230	11894	6506	9256			
0.60atm	9754	8964	6676	11539	5937	7672			
0.75atm	3181	3323	986	4538	4988	3093			
Mean	0.400	0423	0.454	0.441	0.284	-			
Rupee/Rupee investment									
0.30atm	0.78	0.81	0.25	1.19	0.91	0.79			
0.45atm	1.22	1.30	0.57	0.73	1.08	1.19			
0.60atm	1.19	1.14	0.53	1.72	1.01	1.12			
0.75atm	0.39	0.42	0.07	0.68	0.85	0.47			
Mean	0.90	0.84	0.36	1.33	0.96	-			

tension produced lowest seed (0.96 t/ha) and stover yield (1.76 t/ha). Similar trend of result was also observed in case of oil content (20.18%) and protein content (34.30%) at 0.45 atmospheric tension. In most of the cases the treatment variation between 0.30, 0.45 and 0.60 atmospheric tension were not very wide. Net return (Rs. 9256/ha) and benefit cost ratio (1.19) were recorded highest values when crop was irrigated at 0.45 atmospheric tension (Table-1).

More number (7) of irrigation was required at 0.30 atmospheric tension. At this atmospheric tension the consumptive use of the crop was also maximum (637.10mm). Consumptive use of water was decreased (Table-2) with the increasing atmospheric tension. Water use efficiency was increased upto irrigation at 0.60 atmospheric tension and thereafter it declined. Jana *et al.* (1984) reported that irrigation at 0.50 atmospheric tension throughout the growth period increased the water use efficiency.

Soil moisture depletion – The crop irrigated at lower (Table-2) tension extracted more moisture from upper soil layer as compared to irrigation at higher atmospheric tension. This might be due to better root development by increasing levels of irrigation that favoured to increase uptake. Single *et al.* (1983) reported that the water removal from the top soil layer increased with the increase in irrigation frequency (Singh *et al.* 1994).

Table-2: Effect of different sources of sulphur and levels of irrigation on consumptive water use efficiency and moisture depletion pattern.

Treatments	No. of Irrigation	Consumption use	Water use efficiency kg/ha/mm	Soil moisture depletion pattern		
				0-15cm	15-30cm	30-45cm
Levels of sulphur						
0.30atm	7	637.10	1.88	241 (38)	208 (33)	189 (27)
0.45atm	6	560.50	2.87	228 (41)	197 (34)	142 (25)
0.60atm	4	428.80	3.37	194 (45)	130 (3)	104 (24
0.75atm	2	303.60	3.17	126 (44)	98 (34)	63 (22)
Mean		482.5	2.82			
Sources of Sulphur						
Elemental S		486.12	2.20	203 (42)	163 (33)	121 (25)
Pyrite		486.25	2.61	200 (41)	166 (34)	120 (25)
Gypsum		495.50	2.99	216 (44)	169 (34)	109 (22)
SSP		485.00	2.80	206 (42)	168 (35)	111 (29)
No Sulphur		440.62	2.35	185 (42)	149 (33)	111 (25)
Mean		478.69	2.59			

Figures in parenthesis indicate percent of moisture depletion

Effect of Sources of Sulphur

Application of sulphur through different sources increased the seed yield by 25 to 43% and stover yield by 21 to 28% over control. Maximum seed (1.49 t/ha) and stover yield (2.05 t/ha) were recorded (Table-1) where the crop received Gypsum as one of the source of sulphur. Sing and Aggarwal (1998) and Singh *et al.* (1999) reported highest seed yield with the use of Gypsum. Higher yield obtained with Gypsum application might be due to the presence of sulphur in more readily available from as well as more solubility of Gypsum to water. The oil (20.59%) and protein (35.48%) content of seed were significantly higher due to application (Table-

1) of Gypsum over other sources. The poor responses of element sulphur to form sulphate. It is well known fact that sulphur has an important role in the synthesis of oil which has been reflected on the result of this experiment. The results are corroborated with the findings of Dubey and Billore (1995) and Das and Das (1995). The sulphur content (0.454%) was also maximum where the crop received sulphur from the Gypsum.

Effect of interaction between levels of irrigation and sources of sulphur

Seed yield (1.88t/ha), oil content (20.89%), protein content (34.44%) and sulphur content of seed (0.471%) were maximum when the crop (Table-1) was irrigated at 0.45 atmospheric tension and applied S @ 40kg/ha in the form of gypsum. But the gypsum is more costly than single super phosphate as a source of sulphur. For that net return (Rs. 11894/ha) and return per rupee investment (1.73) were showed maximum where the crop received irrigation at 0.45 atmospheric tension along with application of sulphur in the form of (Table-1) single super phosphate.

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