Indian J. Plant Physiol., Vol. 10, No. 4, (N.S.) pp. 333-337 (Oct.-Dec., 2005)

ANALYSIS OF GROWTH AND PRODUCTIVITY OF SESAME (*SESAMUM INDICUM*) IN RELATION TO NITROGEN, SULPHUR AND BORON

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Received on 22 Aug., 2003, Revised 6 Oct., 2005

SUMMARY

A field experiment was conducted during summer season of 2001 and 2002 to study the effect of nitrogen (N), sulphur (S) and boron (B) on physiological parameters in relation to productivity of sesame (*Sesamum indicum*) on Gangetic alluvial land. Application of N, S and B improved the physiological parameters, *viz.* leaf area index (LAI), biomass production (BM), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and increased yield attributes which eventually resulted in higher seed yield. Application of 90 kg N, 50 kg S and 1 kg B ha^{-1} increased the seed yield of sesame by 94.2, 30.4 and 10.4% respectively over their respective control. Increase in level of N and S increased agronomic and physiological efficiency of respective nutrient. Among the nutrients applied, B showed the maximum agronomic and physiological efficiency.

***Key words* : Boron, growth, nitrogen, sesame, sulphur, yield attributes.**

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oilseed crop in the tropics as major source of high quality, unique edible oil and thus occupies premier place in farming systems. There is a need to increase its productivity through manipulation of management practices. Since yield is the manifestation of various physiological processes occurring in plants, these processes are usually modified by management practices in an environment. Variation in productivity of a crop occurs due to variation in growth parameters. The growth parameters are usually influenced by various management and external factors. Among the various management factors, nutrient management events profound effect on various growth contributing characters in a given environmental condition. Nitrogen is a key nutrient for proteins and carbohydrate synthesis and plant growth and development (Thakur *et al*. 1998). Sulphur is indispensable for the synthesis of certain amino acids and is also constituent of glutathionate which plays important role in plant respiration and in synthesis of essential oils (Goswami 1986). The primary role of boron in cell wall biosynthesis, phenol metabolism and plasma integrity is well established (Marschner 1995). Hence the present experiment was undertaken to study the physiological and yield responses of sesame to nitrogen (N), sulphur (s) and boron (B) applications.

MATERIALS AND METHODS

The field experiment was conducted during the summer season (February to May) of 2001 and 2002 at the Experimental Farm of Calcutta University, Baruipur, West Bengal on Gangetic alluvial soil (Entisol) having organic carbon 0.72%, available P 30 kg ha^{-1}, available K 260 kg ha^{-1}, available S 14 kg ha^{-1}, available B 0.58 ppm with pH 6.0. The treatments consisting of 4 levels

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of N (0, 30, 60 and 90 kg ha^{-1}), 3 levels of S (0, 25 and 50 kg ha^{-1}) and 2 levels of B (0 and 1 kg ha^{-1}) were tested in a factorial design with 3 replications after harvest of *aman* (photoperiodically season bound) rice. Sesame variety 'B-67' was sown in rows 30 cm apart with intra-plant distance of 10 cm during February. Recommended doses of 60 kg N P_2O_5 and 40 kg K_2O ha^{-1} along with S and B as per treatment were applied at seeding. The N was applied in 2 equal doses, half at sowing and half at flowering stages. Plant sampling for dry matter and leaf area were done at 30 days interval till harvest commencing from 30 days after sowing the crop and growth parameters were computed. Growth analysis was done by using the formulae as suggested by Radford (1967).

RESULTS AND DISCUSSION

Physiological growth parameters

The leaf area index (LAI) of sesame was affected significantly due to different fertilizer treatments at all the crop growth stages (Table 1). The LAI increased with increase in age of the crop and reached maximum at 70 days after sowing and thereafter started declining due to leaf senescence irrespective of treatments. Application of N, S and B to sesame resulted in increased in LAI at all crop growth stages. Increase in LAI at higher levels of N, S and B might be accounted for more activities of meristematic tissues of plant, increasing number and size of cell, which ultimately increased total photosynthetic surface area and LAI of plants.

Biomass production increased at a slow rate up to 50 days after sowing, thereafter, it increased at a faster rate up to 90 days for all the treatments. Application of N, P and B increased the biomass production favourably from an early stage and the differences further enlarged at successive later stages. In general, increase in N, S and B levels increased biomass production up to their highest levels of nutrients at all the crop growth stages (Table 2) and it was possibly due to the rapid conversion of synthesized carbohydrates into proteins and thus increased the number and size of cell, which might have

Table 1. Growth parameters of sesame at different growth stages under variable N, S and B application

Treatments	Leaf area index (LAI)				Biomass production (g plant^{-1})			
	Days after sowing							
	30	50	70	90	30	50	70	90
N levels (kg ha^{-1}) :								
0	0.032	0.184	0.380	0.264	1.29	4.68	7.85	9.40
30	0.037	0.179	0.373	0.263	1.30	4.58	8.14	9.82
60	0.041	0.208	0.418	0.287	1.38	5.18	9.12	10.59
90	0.044	0.224	0.449	0.299	1.46	5.52	10.08	11.50
CD (P = 0.05)	0.001	0.010	0.014	0.010	0.04	0.33	0.96	0.87
S levels (kg ha^{-1}) :								
0	0.034	0.182	0.381	0.265	1.28	4.61	7.87	9.47
25	0.039	0.187	0.385	0.269	1.33	4.81	8.63	10.09
50	0.042	0.190	0.388	0.272	1.35	4.97	9.45	10.88
CD (P = 0.05)	0.001	NS	NS	NS	0.04	0.33	0.96	0.87
B levels (kg ha^{-1}) :								
0	0.033	0.185	0.382	0.266	1.30	4.66	7.90	9.54
1	0.040	0.187	0.385	0.269	1.33	4.87	8.97	10.09
CD (P = 0.05)	0.0008	NS	NS	NS	NS	NS	0.68	NS

caused increase in number and size of leaves, plant height and thereby increase in biomass production.

The crop growth rate (CGR) gradually increased with crop age and reached its peak during 50-70 days and thereafter it declined (Table 2) due to natural leaf senescence. Maximum CGR was noted with higher level of N, S and B application (Table 2). Higher CGR associated with higher rates of fertilization was mainly due to the improvement in plant growth, dry matter and leaf area under such fertilization practices. The relative growth rate (RGR), in general, under all the treatments, reached its peak between 30 and 50 days, and then decreased sharply between 70 and 90 days (Table 2). The mean RGR was, in general higher with increase in rate of N, S and B fertilization. Application of N, S and B showed progressively higher RGR than each respective level of this individual nutrients at all growth stages. The higher LAI attained through fertilization with N, S and B led to high photosynthetic efficiency, which contributed to higher RGR. The net assimilation rate (NAR) increased between 30 and 50 days but decreased gradually between 70 and 90 days (Table 2), probably due to mutual shading. Nitrogen application significantly affected NAR. The increase in NAR of sesame at higher levels of N could be due to more leaf area and crop growth rate. There was however no discernible significant effect of either S or B on NAR. However, higher NAR during 70-90 days at no S is attributable to increased RGR values under this treatment.

Seed yield

The seed yield increased significantly with successive increase in N levels up to 90 kg ha^{-1} (Table 3). There was 94.2% higher seed yield with 90 kg N ha^{-1} over no N due to better supply of N which improved plant growth and increased yield attributes resulting in higher seed yield

Table 2. Growth parameters of sesame under variable N, S and B application (mean of 2 years pooled data)

Treatments	CGR (g plant^{-1} day^{-1})			RGR (g g^{-1} day^{-1}) Days after sowing			NAR (g cm^{-2} day^{-1})		
	30-50	50-70	70-90	30-50	50-70	70-90	30-50	50-70	70-90
N levels (kg ha^{-1}) :									
0	0.162	0.153	0.070	0.025	0.011	0.004	0.003	0.001	0.0004
30	0.164	0.177	0.073	0.026	0.012	0.003	0.005	0.002	0.0005
60	0.189	0.197	0.077	0.028	0.012	0.004	0.006	0.002	0.005
90	0.203	0.226	0.084	0.029	0.013	0.003	0.007	0.003	0.0006
CD (P = 0.05)	0.016	NS	0.002	0.001	NS	NS	0.006	NS	0.00008
S levels (kg ha^{-1}) :									
0	0.162	0.151	0.071	0.026	0.010	0.005	0.005	0.001	0.0006
25	0.174	0.190	0.073	0.027	0.012	0.003	0.005	0.002	0.0005
50	0.181	0.223	0.084	0.028	0.013	0.004	0.005	0.003	0.0005
CD (P = 0.05)	NS	0.048	0.001	NS	NS	NS	NS	0.0006	0.00008
B levels (kg ha^{-1}) :									
0	0.164	0.154	0.072	0.027	0.011	0.003	0.005	0.002	0.0005
1	0.176	0.204	0.080	0.027	0.012	0.004	0.005	0.002	0.0005
CD (P = 0.05)	NS	NS	0.001	NS	NS	NS	NS	NS	0.00006

Table 3. Yield attributes and yield of sesame under variable N, S and B application (mean of 2 years pooled data)

Treatments	Capsules (Number plant^{-1})	Capsule length (cm)	Seeds (Number capsule^{-1})	1000-seed weight (g)	Seed yield (g plant^{-1})	Seed yield (q ha^{-1})
N levels (kg ha^{-1})						
0	27.4	0.94	50.10	3.31	3.50	6.20
30	27.5	0.96	54.34	3.46	4.80	7.12
60	27.8	0.98	56.42	3.54	5.94	8.75
90	28.0	1.03	57.54	3.60	6.80	11.08
CD (P = 0.05)	NS	0.007	1.26	NS	0.22	0.18
S levels (kg ha^{-1})						
0	27.5	0.96	51.01	3.40	4.50	7.67
25	27.6	0.97	55.43	3.47	5.40	8.01
50	27.7	0.98	57.37	3.54	5.85	9.70
CD (P = 0.05)	NS	0.006	1.08	NS	0.20	0.16
B levels (kg ha^{-1})						
0	27.6	0.95	54.05	3.45	4.99	8.40
1	27.7	0.98	55.15	3.49	5.50	9.17
CD (P = 0.05)	NS	0.005	0.88	NS	0.16	0.13

(Thakur *et al*. 1998). Similarly, application of S significantly increased the seed yield. This increase in yield was 30.4% with 50 kg S ha^{-1} over the control which is attributed to stimulatory effect of S on the synthesis of chloroplast and protein which in turn promoted greater photosynthesis, ultimately resulted in higher seed yield (Subrahmaniyan *et al*. 1999). Application of 1 kg B ha^{-1} resulted in 10.4% higher seed yield over the control. This might be due to increased carbohydrate metabolism (Duggar and Gauch 1954) with B application. The difference in seed yield under individual treatments of N, S and B fertilization could be related to difference in biomass, LAI, CGR, RGR and NAR. The biomass, LAI, CGR and RGR improved considerably with increase in N, S and B application. Increase in LAI biomass, CGR and RGR at higher level of B compensated for lower NAR at B fertilization. Hence increase in seed yield seems to be associated with simultaneous LAI, biomass CGR, RGR and NAR due to efficient photosynthesis and assimilation of sesame with N, S and B fertilization.

Nutrient uptake

The total uptake of N, S and B by the crop were increased with increasing levels of N (Table 4). Similarly, N, S and B uptake by the crop increased with increasing levels of S. The increased rate of S application enhanced the uptake of S and B. Application of B increased the uptake of N, S and B by the crop at harvest. This could be ascribed to their greater availability in root environment along with extraction and transport towards plant system.

Apparent recovery

Apparent recovery of N was increased from 39.66% at 30 kg N ha^{-1} to 48.88% with 90 kg N ha^{-1} (Table 4). Apparent recovery of S was reduced from 36.4% at 25 kg S ha^{-1} to 23.2% at 50 kg S ha^{-1} application. Among the nutrients, B recorded the lowest apparent recovery of only 13.0% B. Higher apparent recovery of S with lower rate of S application might be due to lower S losses and synchronization of judicious S supply with crop need.

Table 4. Nutrient uptake in sesame as affected by N, S and B applications (mean of 2 years pooled data)

Treatments	Nutrient uptake (kg ha^{-1})		
	N	S	B
N levels (kg ha^{-1})			
0	36.2	5.8	0.83
30	51.0	8.9	0.89
60	72.1	12.8	0.93
90	84.3	14.0	0.98
CD (P = 0.05)	1.87	0.34	0.032
S levels (kg ha^{-1})			
0	40.3	6.8	0.87
25	51.0	15.9	0.91
50	60.4	18.4	0.95
CD (P = 0.05)	1.62	0.30	0.028
B levels (kg ha^{-1})			
0	41.2	6.7	0.84
1	46.4	11.5	0.97
CD (P = 0.05)	1.32	0.24	0.022

Nutrient efficiency

Agronomic efficiency of N and S increased progressively with increase in levels of N and S application (Table 5). Application of B recorded the highest agronomic efficiency over N and S application (Table 5). Higher availability of nutrients with application of higher doses of N and S led to improvement in seed yield and consequently higher agronomic efficiency. Similarly, physiological efficiency increased with corresponding increase in level of N and S fertilizer. Application of N at 90 kg ha^{-1} and S at 50 kg ha^{-1} gave higher values of physiological efficiency. Physiological efficiency was highest with B application at 1 kg hg^{-1}. It is probably that at higher levels of N, S and with B application the absorbed nutrients are efficiently used for grain formation at higher levels.

Table 5. Apparent recovery agronomic and physiological efficiency of sesame due to variable N, S and B application (mean of 2 years pooled data)

Treatments	Apparent recovery (%)	Agronomic efficiency (kg kg^{-1})	Physiological efficiency (kg kg^{-1} removed)
N levels (kg ha^{-1})			
30	39.66	3.06	7.73
60	43.33	4.25	9.77
90	48.88	5.42	11.09
S levels (kg ha^{-1})			
25	36.40	1.36	3.73
50	23.20	4.06	17.5
B level (kg ha^{-1})			
1	13.00		592.30

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