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Influence of plant growth regulators on growth, morpho-physiological characters and yield of summer sesame (*Sesamum indicum* L. *cv.* Rama) under moisture stress

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Abstract

Field experiments were conducted with sesame (*Sesamum indicum* L. *cv.* Rama) for two years (1997 and 1998) to study the effect of three level of irrigation (F+C, B+C, B+F+C) and two growth regulators (CCC, 200 ppm CCC; 100 ppm and BX-112, 100 ppm; BX-112, 50 ppm) on growth (root and shoot length, average number of primary branches/plant), morpho-physiological growth parameters(LAI, LAD, CGR and NAR), yield attributing parameters(average number of capsule/plant, average number of seeds/capsule) and seed yield. Irrigation at B+F+C stage showed significant effect on these parameters. Among the growth regulators, CCC, 200 ppm showed remarkable results on these parameters and seed yield. Seed yield in CCC,200 ppm treatment was more than 53 % in comparison to water soaked seeds. The interaction between irrigation and PGR showed better seed yield and it was concluded that the growth regulator CCC might be utilized for enhancement of seed yield of summer sesame under field condition.

List of abbreviations: F+C-irrigation at peak flowering and capsule development stages, B+C-irrigation at branching and capsule development stages, B+F+C-irrigation at branching, peak flowering and capsule development stages. CCC-cycocel, BX-112-prohexadione calcium, PGR-plant growth regulator, LAI-leaf area index, LAD-leaf area duration, CGR-crop growth rate, NAR-net assimilation rate.

Introduction

Sesame (*Sesamum indicum* L.) is an important oilseed crop and it is generally cultivated in semi-arid to tropical zones with unassured rainfall and/or limited supply of irrigation water. Sesame produces an excellent crop with a rainfall of 500-600 mm (Weiss 1983) and some stages of crop growth are critical for soil moisture and are highly susceptible to drought at seedling stage. It is a poor starter (Joshi 1985) and once established, sesame is capable of withstanding a higher degree of water stress (Weiss 1983). Maximum water absorption occurs at flowering supporting the contention that water stress at this period has major reducing effect on yield (Weiss 1983). But reports suggest that crop plant can resist drought to a certain extent with PGR treatment (Xu Taylor 1982) through the alteration of some physiological activity. Two growth regulators, *viz.* CCC (2-chloroethyl trimethyl ammonium chloride) and BX-112 (Calcium 3.5-diozo-4 propionyl cyclohexone carboxylate) were applied to study their effects on growth, morpho-physiological characters, yield attributing characters and seed yield of summer sesame under moisture stress condition of field.

Material and methods

Field experiments with seasme (*Sesamum indicum* L. *cv.* Rama) were conducted during summer season of 1987 and 1998 at the agriculture firm of Visva-Bharati university, India at Latitude 23° 39' N and longitude 87° 2' E. Five levels of PGR (no growth regulator, CCC, 200 ppm, CCC, 100ppm BX- 112, 100 ppm and BX-112 50ppm in sub–plot and three levels of irrigation(F+C, B+C, B+F+C) in main plot. The experiment was conducted in split plot design. The branching started on 35 DAS, peak flowering stage was on 55 DAS and capsule stage was on 75 DAS. The number of replication was three. Individual plot size was 4 m x 3 m. Soil was sandy loam in texture, low in N content, high in P and medium in K content. Recommend doses of N-P_2O_5-K_2O @ 80-40-40 kg/ha were applied during final land preparation. As per sub-plot treatments, sesame seeds were soaked overnight before sowing and spraying of PGR was made at the commencement of flowering. The crop received 18.2 cm and 17.0 cm. rainfall in 1997 and 1998 respectively. In 1998, distribution of shower in respect of time was good from the normal crop cultivation point of view.

Among different growth characters, leaf area was measured with an electronic leaf area meter. LAI and NAR were determined following the method of William (1946) and Watson (1952). LAD or photosynthetic potential was determined by multiplying the mean LAI over the particular time period (Kvet, 1978). CGR was calculated by the formula:

$$CGR\ (g \cdot m^{-2} \cdot day^{-1}) = 1/p\ (\ w_2 - w_1 / t_2 - t_1\ )$$

where w_1 and w_2 are dry weights of plant samples collected from equal areas of ground (P) at times t_1 and t_2 respectively. Plants were uprooted from the soil with a spade taking much care about having possible accurate root length. For statistical analysis of the observed tabulated data, Panse & Sukhatme (1978), Gomez & Gomez (1984) were followed.

Table 1. Effect of stages of irrigation and growth regulators on morphology, yield attributing characters and yield.

Treatment	Root length (cm)		Shoot length (cm)		Avg. no. of primary branches/plant		Avg. no. of capsule/plant		No. of seeds/capsule		Seed yield ($kg \cdot ha^{-1}$)		Pooled seed yield ($kg \cdot ha^{-1}$)
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	
Stages of irrigation													
F+C	22.1	23.5	98.4	102.4	4.9	5.3	30.8	34.4	43.6	45.1	896.6	1133.3	1014.9
B+C	22.4	23.3	99.1	104.4	5.1	5.3	35	35.1	44.8	44.0	1172.6	1155.6	1164.1
B+F+C	22.5	24.2	99.8	108	5.2	5.6	35.7	36	44.7	45.6	1185.8	1179.1	1182.4
LSD (P=0.05)	0.21	0.4	0.1	1.42	0.12	0.21	1.37	NS	0.51	0.84	22.9	7.8	11.3
PGR													
Water soaked seed	19.2	20.4	101	118.9	3.9	4.2	27.4	29.1	39.6	38.2	819.6	907.5	863.6
CCC, 200 ppm	25.5	26.3	96.7	94.8	6.1	6.2	37.5	41.2	48.5	49.4	1264.6	1379.2	1321.9
CCC, 100 ppm	24.0	24.8	99.2	100.8	5.5	5.7	34.3	36.1	44.7	46.8	1090.0	1217.8	1153.9
BX-112,100 ppm	21.9	23.7	98.4	103.0	5.4	5.6	36.5	35.3	46.3	46.0	1170.0	1217.8	1193.9
BX-112, 50 ppm	21.2	23.0	99.7	107.1	4.7	5.2	33.4	34.1	44.7	44.0	1080.6	1057.6	1069.1
LSD (P=0.05)	0.21	1.19	0.83	4.03	0.25	0.3	1.3	2.56	2.5	2.36	32	9.0	16.8

Results

Among the irrigation level, B+F+C had significant effect on all morphological growth parameters, yield attributing characters and yield. At times B+C had at par effect with B+F+C. But B+F+C contributed significantly the highest pooled value of seed yield (1182.4 kg/ha) which is precious from the agronomical point of view (Table 1). Growth regulators had better effect than water soaked seeds and among the growth regulators, CCC,200 ppm was significantly effective which contributed 53 % more seed yield over no PGR treatment (Table 1). With the advancement of crop growth stages, LAI was increased from 35 DAS to 55 DAS and then decreased due to senescence and fall of leaves. Except on 35 DAS, both of B+F+C and CCC, 200 ppm had significant desirable effect on LAI in both the years (Table 2). Regarding LAD in both the years, B+C and B+F+C had at par effect during 35-55 DAS but B+F+C was significantly effective in the next 55-75 DAS, but among the PGRs, CCC, 200 ppm always showed superiority (Table 2) over others. Regarding CGR, B+F+C had higher rate of dry matter accumulation in both the years except during 15-35 DAS. Among PGRs CCC, 200 ppm had the same trend as B+F+C and water soaked seeds always proved their inability to maintain the pace with of PGRs. Maximum crop growth rate was recorded during 35-55 DAS (Table 3).

Discussion

In these experiments, shorter root and shoot length in F+C may be due to withholding of irrigation during branching stage. B+F+C produced longest root and shoot where irrigation was given at branching in addition to peak flowering and capsule development stage and it may be due to early good establishment of roots in hot summer season which could keep the pace of root and shoot elongation at the later stages of crop growth. These results are in support of findings of Weiss (1983) and Joshi (1985) who reported that for seedling establishment and growth early watering is essential. No growth regulator treated plot showed shorter root length and longer shoot length, which is not desirable in summer season and in dry region for this crop. But PGRs had just the reverse effect, which favoured the better crop production. These findings confirmed the findings of *Kar et al* (1989), Nakayama *et al.* 1990, Rademacher (1991), Ryu & Lee (1993) in other crops with CCC, BX-112 and other growth regulators. A greater number of branches per plant of the PGR treated plots over control was possible due to the breaking of apical dominance (Rademacher, 1991).

Table 2. Effect of stages of irrigation and growth regulators on leaf area index (LAI) and leaf area duration (LAD) at different stages of crop growth.

Treatment	LAI						LAD (days)			
	35 DAS		55 DAS		75 DAS		35-55 DAS		55-75 DAS	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Stages of irrigation										
F+C	0.579	0.668	2.602	2.896	1.53	1.695	31.8	35.6	41.3	45.9
B+C	0.628	0.664	3.156	2.963	1.73	1.742	37.8	39.6	48.9	50.4
B+F+C	0.578	0.655	3.214	3.298	1.95	2.062	37.9	39.5	51.7	53.6
LSD (P=0.05)	0.035	N.S.	0.098	0.077	0.25	0.069	0.9	0.94	2.34	1.16
PGR										
Water soaked seed	0.561	0.598	2.462	2.616	1.38	1.463	30.2	32.2	38.4	40.8
CCC, 200 ppm	0.602	0.743	3.357	3.6	2.14	2.345	39.6	43.4	55	59.5
CCC, 100 ppm	0.612	0.685	3.058	3.248	1.76	1.894	36.7	39.3	48.2	51.4
BX-112,100 ppm	0.61	0.65	3.207	3.215	1.8	1.776	38.2	38.7	50	49.9
BX-112, 50 ppm	0.591	0.634	2.868	3.137	1.6	1.686	34.6	37.7	44.7	48.2
LSD (P=0.05)	0.01	0.018	0.097	0.038	0.17	0.085	0.9	0.43	2.15	0.89

A greater number of capsules per plant and seeds per capsule in B+F+C and PGR treated plots is due to a greater number of branches per plant and vigorous size of capsule. Higher seed yield in B+F+C supports the work of Majumdar and Roy (1992). The higher seed production in CCC treated plots is due to the enhancement of all yield attributing characters in these plants over other plants. With maturity of crop growth, LAI increased due to newly emerged branches and leaves and then LAI decreased gradually due to leaf senescence. Kar et al (1989) reported similar results with some other growth regulators - dikegulac sodium, CCC and SADH in safflower plants. Higher CGR was noticed with higher LAI and this was probably due to higher light interception by leaves followed by higher photosynthesis and accumulation of more photosynthates, which led to the ultimate seed yield. These results are in conformity with the experimental results of Ries & Wert (1977), Menon & Srivastava (1984), Tesar (1984). LAD was dependent upon LAI. Higher mean LAI (Table 2) during 55-75 DAS was the cause of higher LAD during that period. NAR was dependent on CGR and mean LAI over the period and it varied accordingly.

From the results obtained in these experiments, it may be concluded that plant growth regulators though their changes in the architecture of this crop enhanced seed yield under moisture stressed conditions of the field.

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Table 3. Effect of stages of irrigation and growth regulators on crop growth rate (CGR) and net assimilation rate (NAR) at different stages of crop growth.

Treatment	CGR ($g \cdot m^{-2} \cdot day^{-1}$)						NAR ($g \cdot m^{-2} \cdot day^{-1}$)			
	35 DAS		55 DAS		75 DAS		35-55 DAS		55-75 DAS	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Stages of irrigation										
F+C	2.84	2.72	17.294	16.317	14.131	12.444	10.867	9.073	6.922	5.358
B+C	2.972	2.746	19.731	17.092	13.83	11.3	10.418	8.549	5.676	4.443
B+F+C	2.884	2.716	20.558	17.26	14.14	14.238	10.836	8.665	5.488	5.254
LSD (P=0.05)	0.017	N.S.	0.394	1.18	0.87	0.503	0.24	N.S.	0.35	N.S.
PGR										
Water soaked seed	2.691	2.6	15.278	12.49	11.388	8.96	10.102	7.781	5.941	4.4
CCC, 200 ppm	2.958	2.94	20.99	20.064	15.632	16.546	10.622	10.163	5.703	5.578
CCC, 100 ppm	2.995	2.726	20.215	17.52	14.278	14.023	11.001	8.91	5.946	5.439
BX-112,100 ppm	2.952	2.716	20.132	17.486	14.135	12.146	10.554	9.052	5.686	4.861
BX-112, 50 ppm	2.895	2.653	19.357	14.888	14.734	11.626	11.255	7.906	6.867	4.82
LSD (P=0.05)	0.072	0.07	0.533	2.751	0.378	2.78	0.389	1.463	0.323	1.113

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