BIOLOGIA PLANTARUM 39 (2): 223-228, 1997

Source-sink relationship in *Abelmoschus esculentum* L.

R.M. BHATT and N.K. SRINIVASA RAO

Division of Plant Physiology and Biochemistry, Indian Institute of Horticultural Research, Hessarghatta, Bangalore - 506 089, India

Abstract

The ontogenetic changes in source-sink relation associated with the manipulation of reproductive sink at different positions on the plant in two okra cultivars (Arka Anamika and Pusa Makhamali) with distinct branching habit (cv. Arka Anamika tends to branch at the middle nodes unlike cv. Pusa Makhamali) were analysed. The cultivar differences for extension growth were nonsignificant except at treatment where all flowers and flower buds upto 8^{th} mode were removed. The reproductive sink reductions resulted in a decrease of total dry matter accumulation per plant to an extent of 13 to 46 % in Arka Anamika and 18 to 34 % in Pusa Makhamali. Fruits on the middle nodes appear to be prominent sinks for photoassimilates in cv. Arka Anamika. The reproductive sink manipulation did not result in any particular change in the trend of photosynthesis, but brought about a significant change in the partitioning of dry matter.

Additional key words: cultivar differences, dry matter accumulation, internal CO_2 concentration, leaf position, okra, photosynthetic rate, stomatal conductance.

Introduction

Fruit production in okra (*Abelmoschus esculentum* L.) is a continuous process and all the transitional stages from the flower bud to 5- to 6-d-old harvestable fruits are present simultaneously on a plant during its ontogeny. During fruiting the vegetative and reproductive sinks exist in a delicate balance as fruits are picked up 6 d after setting. The pods draw their photosynthate predominantly from subtending leaf and the growth stage of the fruit determines the proportion of photosynthates translocated from the source leaf (Bhatt and Srinivasa Rao 1993b).

The present study attempts to understand the changes in plant growth, carbon exchange rate and related phenomena associated with manipulation of reproductive sink at different positions on the plant.

Received 9 February 1996, *accepted* 7 August 1996.
Acknowledgements: The authors are grateful to the Director, I.S. Yadav, of the Institute for providing necessary facilities, and Mr. C. Muniraju and Mr. A.D.D.V.S. Nageswara Rao for technical help. Contribution No. 5/96.

Material and methods

Two okra (*Abelmoschus esculentum* L.) cultivars, cv. Arka Anamika and cv. Pusa Makhamali were selected for their variation in overall growth. Arka Anamika has the potential for lateral branching and leading to second flush of flowers and fruits formation at the middle nodes, while Pusa Makhamali lacks those characteristics. They were grown in plots of 3 × 3 m in three replications at spacing of 50 × 30 cm during June - October 1994. N, P and K were given in doses corresponding to 125, 75 and 62.5 kg ha^{-1}. At flowering stage the plants were divided into 5 groups: T1 - flowers and flower buds kept intact (control), T2 - flowers and flower buds from 1^{st} to 4^{th} nodes (lower nodes) removed, T3 - flowers and flower buds from 5^{th} node upwards removed, T4 - flowers and flower buds from 5^{th} to 8^{th} nodes (middle nodes) removed, T5 - all flowers and flower buds upto 8^{th} node removed.

After flowering, observations on leaf photosynthetic rate (P_N), stomatal conductance (g_s) and internal CO_2 concentration were made in 10 d intervals using Portable Photosynthesis System, model *LCA-3* (*ADC*, Hoddesdon, UK). The mean PAR irradiance ranged from 900 to 1000 µmol m^{-2} s^{-1} and leaf temperature from 27 to 30 °C. P_N was measured on upper and lower leaves and the average P_N was given in the text. At late fruiting stage four plants were uprooted and plant parts, after separation, were dried in an oven at 80 °C for 48 h to record dry matter.

Results and discussion

The reduction of reproductive sink at different positions on the plant affected plant growth in both the cultivars and the magnitude varied with the cultivar (Table 1). Bhatt and Srinivasa Rao (1993) found that removal of reproductive sink regularly induced higher extension growth. The increase in the extension growth rate was not significant, but in the plants where flowers and flower buds were regularly removed upto 8^{th} node (T5), it was found to be 61 and 33 % over control in Arka Anamika and Pusa Makhamali, respectively. The position of the reproductive sink on the plant from where it was removed determines the rate of extension growth and stem girth. Non-significant variation in specific leaf mass (SLM) between control and treated plants of both the cultivars supported our earlier results that the reproductive sink removal do not increase the accumulation of dry matter in the leaves (Bhatt and Srinivasa Rao 1993).

The decrease in total dry matter accumulation per plant was 13 to 46 % in Arka Anamika and 18 to 34 % in Pusa Makhamali due to reduction of the reproductive sink on different positions of the plant (Table 1). However, both the cultivars did not differ significantly in the dry matter between control and the plants where reproductive sink was regularly removed upto 8^{th} node. Earlier studies on okra in summer showed that the regular removal of flowers and pods resulted in an increase in the total dry matter accumulation (Bhatt and Srinivasa Rao 1993). In Arka Anamika the accumulation in total dry matter was minimum (133.1 g $plant^{-1}$) in the

Table 1. Morphological parameters as influenced by reproductive sink manipulation at different positions in two cultivars of okra. Treatments as defined in Materials and methods.

Parameters	cv. Arka Anamika					cv. Pusa Makhamali						Cv.	Treat.	Inter.
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5				
Height [cm]	113.0	154.0	121.0	114.0	182.0	164.0	169.0	194.0	179.0	218.0	SEM	2.0	3.2	4.6
											LSD	5.9	9.4	13.2
Stem girth [mm]	12.6	14.4	13.0	12.0	16.3	16.8	16.1	15.5	12.0	20.4	SEM	0.4	0.7	1.0
											LSD	1.4	2.2	3.1
Total dry mass [g plant^{-1}]	202.8	163.5	133.1	166.1	210.5	266.8	214.0	185.2	145.4	232.8	SEM	8.4	13.4	19.0
											LSD	25.1	39.7	56.2
SLM (upper leaf) [mg m^{-2}]	85.0	76.0	90.0	82.0	86.0	91.0	78.0	84.0	99.0	91.0	SEM	2.0	3.2	4.5
											LSD	6.0	9.5	13.5
SLM (lower leaf) [mg m^{-2}]	64.4	57.0	67.0	62.0	65.0	68.0	58.0	63.0	75.0	69.0	SEM	1.5	2.5	3.5
											LSD	4.6	7.3	10.4

SEM - standard error of mean, LSD - least significant difference at $P \leq 0.05$.

Table 2. Effect of reproductive sink manipulation at different positions on dry matter [g] partitioning to different plant parts in two cultivars at late fruiting stage. Treatment as defined in Materials and methods. SBF - side branch fruits. Treatments as defined in Materials and methods.

Treatment	cv. Arka Anamika							cv. Pusa *Makhamali*						
	Leaf	Stem	Pod					Leaf	Stem	Pod				
			Lower	Middle	Upper	SBF	Total			Lower	Middle	Upper	SBF	Total
T1	21.0	23.0	19.0	21.0	14.0	2.0	56.0	22.0	33.0	17.0	14.0	14.0	-	45.0
T2	21.0	32.0	-	27.0	18.0	2.0	47.0	25.0	39.0	-	22.0	14.0	-	36.0
T3	29.0	40.0	27.0	-	-	2.0	29.0	26.0	49.0	25.0	-	-	-	25.0
T4	22.0	28.0	22.0	-	23.0	5.0	50.0	17.0	44.0	24.0	-	15.0	-	39.0
T5	27.0	48.0	-	-	20.0	5.0	25.0	27.0	53.0	-	-	20.0	-	20.0

Table 3. Net photosynthetic rate, P_N [mmol m^{-2} s^{-1}], stomatal conductance, g_s [mol m^{-2} s^{-1}] and internal CO_2 concentration, c_i [μmol mol^{-1}] in relation to reproductive sink modification at different time after flowering [d]. Treatments as defined in Materials and methods.

Cultivar		10 d			20 d				30 d			
		T1	T2	T5	T1	T2	T3	T5	T1	T2	T3	T5
cv. Arka Anamika	P_N	21.0	17.7	14.1	23.2	24.0	20.2	24.4	25.0	25.8	26.8	24.4
	g_s	1.6	1.8	1.6	0.5	0.5	0.6	0.3	0.8	0.6	0.7	0.6
	c_i	256	269	287	218	200	226	200	226	200	200	211
cv. Pusa Makhamali	P_N	25.7	19.5	19.0	24.1	23.3	26.5	23.8	24.8	23.6	23.6	23.3
	g_s	1.4	1.6	1.5	0.4	0.4	0.6	0.5	0.8	1.0	1.1	1.2
	c_i	258	267	268	200	215	210	218	220	221	232	234

plants where reproductive sink from 5th node upwards was removed (T3). However, in Pusa Makhamali the dry matter was minimum (144.5 g $plant^{-1}$) in the plants where reproductive sink was removed from 5th to 8th nodes (middle nodes) (T4) (Table 1). This indicates that there was cultivar variation in dry matter accumulation in relation to the reproductive sink modification. However, the effect of sink modification on total dry matter accumulation depends primarily on the position of the reproductive sink on the plant.

Similar to dry matter accumulation, there was a significant change in the pattern of its partitioning to different parts (Table 2). There was an increase in the percent dry matter accumulation in the vegetative parts of the plants, especially in the stems. The cultivar differences for partitioning are significant only for stem and fruit, and supported our earlier findings that the stem is a strong sink for photoassimilates as it acts as a storage organs (Bhatt and Srinivasa Rao 1993, Srinivasa Rao and Bhatt 1989).

The accumulation of dry matter in the fruits was relatively more in Arka Anamika than Pusa Makhamali irrespective of the treatments. The dry matter partitioned to the fruits in control plants was 56 % in Arka Anamika and 45 % in Pusa Makhamali. The middle node fruits accumulated maximum dry mass (21 %) in Arka Anamika while in Pusa Makhamali (17 %) in the lower node fruits. The removal of reproductive sink from lower nodes (T2) increased the partitioning of dry matter to the middle node fruits in both the cultivars. However, in (T4), the partitioning between lower and upper fruits was almost equal in Arka Anamika. However, in Pusa Makhamali the partitioning to lower fruits was significantly higher (24 %) after the removal of reproductive sink from the middle node. In Arka Anamika T4 and T5 increased the formation of lateral branches and fruits on the middle nodes of the plant, while it was absent in any of the treatments in Pusa Makhamali. In Arka Anamika there was an increase in the partitioning of dry matter to lateral branch fruits in T4 and T5. This indicates that the middle node fruits were stronger sinks for photoassimilates in Arka Anamika. Although, Pusa Makhamali has higher total dry matter compared to Arka Anamika, the partitioning of dry matter to the fruits was superior in Arka Anamika.

No particular trend was found in photosynthetic rate (P_N) after the removal of reproductive sink from different positions on the plant, it decreased initially in the treated plants of both the cultivars (Table 3). There was a marginal increase in P_N from mid-late reproductive stage (30 d after flowering) only in treated plants. There was no significant difference in P_N between control and treated plants in both the cultivars. However, in Capsicum about 30 % reduction in P_N was found after removal of the growing fruits (Hall and Milthorpe 1987). There was also no significant difference in the stomatal conductance between the control and treated plants, but considerable difference in the internal CO_2 concentration (c_i) in both the cultivars. In okra it was found that the rate of decrease in P_N during the ontogeny was slow in the plants where flowers and fruits were removed regularly indicating the maintenance of leaf activity (Bhatt and Srinivasa Rao 1993).

The study revealed that selection for partitioning would be more beneficial than P_N alone, to increase productivity in okra, as genotypes appear to differ significantly for partitioning rather than P_N.

References

Bhatt, R.M., Srinivasa Rao, N.K.: Photosynthesis and dry matter distribution as influenced by reproductive sink manipulation in okra (*Abelmoschus esculentum* L.). - Indian J. Plant Physiol. **5**: 1-3, 1993a.

Bhatt, R.M., Srinivasa Rao, N.K.: Translocation of photosynthetic assimilate during pod development in okra (*Hibiscus esculentus*). - Indian J. agr. Sci. **63**: 708-711, 1993b.

Hall, A.J., Milthorpe, F.L.: Assimilate source-sink relationship in *Capsicum annuum* L. III. The effect of fruit excision on photosynthesis and leaf and stem carbohydrates. - Aust. J. Plant Physiol. **5**: 1-3, 1978.

Srinivasa Rao, N.K., Bhatt, R.M.: Distribution of ^{14}C sucrose applied to leaves at different nodes of okra (*Abelmoschus esculentum* L.) during flowering and early pod growth. - Ann. appl. Biol. **115**: 521-527, 1989.