INFLUENCE OF POD LOAD ON RESPONSE OF OKRA TO WATER STRESS

R.M. BHATT* AND N.K. SRINIVASA RAO

Indian Institute of Horticultural Research, Hessarghatta , Bangalore-560089, India

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SUMMARY

Effect of fruit load on plant responses to water stress was studied in two cultivars (Arka Anamika and Parvani Kranti) of okra (*Abelmoschus esculentum* L). Plants were divided into two groups before imposing the stress at reproductive stage: (i) in one group the pods were regularly harvested (depodded) and (ii) in other group the pods were not harvested (podded). Plants were subjected to water stress for five weeks. Leaf area reduction was more in podded plants of both the cultivars under water stress. Water stress resulted in significant decrease in photosynthetic rate. There was 12 to 40 % reduction in photosynthesis in depodded and 16 to 52 % in podded plants of Arka Anamika, while it was 2.5 to 54 % in depodded and 1.0 to 66 % in podded plants of Parvani Kranti. Maximum reduction in total dry matter accumulation was 51% in depodded plants of Arka Anamika, while 43% in podded plants of Parvani Kranti under the stress. Though there was recovery in physiological parameters after releasing the stress, a reduction of 47 (depodded) to 55% (podded) in biological yield was found in Arka Anamika and 10 (depodded) to 46% (podded) in Parvani Kranti in stressed plants at final harvest of crop. The results indicated that the pod influences the plant responses to water stress as indicated by the differences in leaf area production, plant height and carbon exchange characteristics in podded and depodded plants during water stress.

***Key worlds*. Growth, Okra, photosynthesis, stomatal conductance, water potential, water stress .**

INTRODUCTION

During the reproductive stage the fruit load increases the photosynthesis and its characteristics in vegetable crops (Bhatt and Srinivasa Rao 1993, Poni *et al*. 1994). The presence of fruits has been reported to increase leaf water potential (Downton *et al*. 1987). It has been reported that water availability interacts with crop load and affects the physiological processes like carbon exchange rate and stomatal conductance (Naor *et al*. 1997). The dynamic relationship between fruit growth and water stress depends upon the severity of the water stress and the bearing of the fruits on the plant. The water stressed plants with heavy crop loads result in significantly reduced fruit dry matter, which is due to source limitations resulting from large carbon demands and water stress induced limitations on photosynthesis (Berman and De jong 1996). In the vegetable crop like okra, because of its indeterminate habit, where development of source and reproductive sink takes place simultaneously, the partitioning of photosynthates is largely influenced by the relationship between source and developing pod. In okra, the seed crop (fruits not harvested and used for seed extraction) and crop used for vegetable (tender fruits harvested regularly) vary in their growth behavior and source sink relationship. The present study was carried out with an objective to understand the physiological responses of okra plants to water stress in relation to its fruit load.

* Corresponding author

MATERIALS AND METHODS

A study was carried out at the experimental station (Hessarghatta, Bangalore) of Indian Institute of Horticultural Research during March-July. Seeds were collected from the Division of Vegetable Crops. Two okra (*Abelmoschus esculentum* L.) cultivars Arka Anamika (having potential for lateral branches) and Paravani Kranti (single stemmed plant with no lateral branches) were grown in the experimental plots of 3 x 3 m in three replications at spacing of 50 x 30 cm. The recommended package of practices were followed to grow the crop (Chadha 2001). Plants were regularly irrigated upto pre-flowering stage. The average photosynthetic photon flux density (PPFD) varied from 900 to 1400 µmol m^{-1} s^{-1} , minimum and maximum temperature between 20-22^{0}C and 33-35 ^{0}C, respectively and relative humidity between 50 and 65 %.

Water stress was imposed by withholding the irrigation at flowering stage for a period of five weeks. At the time of imposing the water stress, plants were divided into two groups to have different fruit loads : i) in one group the pods were regularly harvested after 4 -5 days of pod setting (depodded); ii) in second group the pods were not harvested (podded). Observations on photosynthesis and stomatal conductance were recorded weekly between 09 : 00 to 11 : 00 after imposing the stress. Plant height, leaf area, leaf water potential, total dry mass accumulation and its partitioning to fruits and roots were recorded before releasing the stress. The biological yield and fruit dry matter was recorded at final harvest of the crop. Photosynthetic rate and stomatal conductance were measured using portable photosynthetic system LCA-3 (ADC, Hoddesdon, UK). The photosynthetic rate was recorded on 4th leaf from top of the plant with Parkinson leaf chamber (area 6.2 cm^2). Flow rate of 400 ml min^{-1} was maintained during the photosynthetic observations. The leaf water potential was observed using water potential system (CR-7, USA). Leaf area was measured using leaf area meter (Li-3000, USA). Plants were uprooted and plant parts, after separation, were dried in an oven at 80 ^{0}C for 48 h to record dry mass.

RESULTS AND DISCUSSION

Plant growth was significantly reduced in plants with regular pod harvest (depodded) and no-pod harvest (podded) (Table 1). A reduction of 9 (podded) to 30% (depodded) in plant height was found in cv. Arka Anamika, while it was 15 (depodded) to 34% (podded) in cv. Parvani Kranti before releasing the stress. Leaf area decreased in podded plants of both the cultivars and further reduced by water stress. This indicates that the pod load influences the cell growth of the plant and it is marked under the stress condition. Berman and Dejong (1996) found that under reduced irrigation the degree of water stress increases with increasing crop load. The reduction in plant height and the leaf area under water stress may be associated with the decline in the cell enlargement and more leaf senescence in the plants where pods were not harvested (podded). There was significant decrease in total dry matter accumulation in depodded and podded plants of both the cultivars under water stress. The pod dry matter was less in the podded plants under water stress, though, the percent dry matter partitioning to pod was more (43% in Arka Anamika and 44.7% in Parvani Kranti) in podded plants. In the depodded plants the pod dry matter accumulation and percent dry matter accumulation were more in both the cultivars in the stressed plants (Table 1). The higher percentage of dry mass to pod in podded plants is associated with the less effect of water stress on partitioning of photosynthates or its remobilization to fruit sinks in these plants.

In the earlier studies, translocation was found to be more tolerant than photosynthesis and respiration (Boyer 1976). Translocation to pod was probably maintained by the mobilization of stored carbohydrate as stem supposed to act as a storage organ in okra (Bhatt and Srinivasarao 1993, 1997). In podded plants of both the cultivars the partitioning of dry matter to root was less under both irrigated and water stress conditions indicating that the retention of pods influence the partitioning of photosynthates to roots.

The photosynthetic rate varied from 18 to 22.8 in depodded and 18.0 to 23.0 µmol m^{-2} s^{-1} in podded plants of Arka Anamika, while it ranged from 19.0 to 23.0 in depodded and 19.0 to 25 µmol m^{-2} s^{-1} in podded of Parvani Kranti under irrigated conditions (Fig. 1). Water stress caused a significant decrease in the photosynthetic rate in both type of plants. There was 12 to 40 % reduction in photosynthesis in depodded and 16 to 52 % in podded plants of Arka Anamika, while it was 2.5 to 54 %

Table 1. Leaf water potential, plant height, leaf area, total dry matter and its partitioning to root and developing pods (values in parenthesis indicate the % dry matter) under water stress at reproductive stage in okra.

Attributes	Variety	Depodded					Podded				
		Irrigated				Stressed	Irrigated				Stressed
Leaf water potential (-Mpa)	Arka Anamika	2.3				3.0	2.0				2.6
	Parvani Kranti	2.2				2.9	2.5				3.0
				V	T	VxT			V	T	VxT
		SEm	=	0.6	0.6	0.08	SEm	=	0.06	0.06	0.09
		CD (5%)	=	NS	0.2	NS	CD (5%)	=	0.23	0.24	NS
Height (cm)	Arka Anamika	148.0				104.5	101.5				92.0
	Parvani Kranti	130.0				110.5	125.5				82.0
				V	T	VxT			V	T	VxT
		SEm	=	2.0	2.0	2.8	SEm	=	0.89	0.89	1.26
		CD (5%)	=	NS	6.9	9.8	CD (5%)	=	3.1	3.1	4.3
Leaf area (cm^2 $plant^{-1}$)	Arka Anamika	3510.0				2943.0	1794.5				1305.5
	Parvani Kranti	2602.0				2345.0	1702.0				1149.5
				V	T	VxT			V	T	VxT
		SEm	=	233.2	233.2	329.8	SEm	=	53.3	53.3	75.4
		CD (5%)	=	NS	NS	NS	CD (5%)	=	NS	184	NS
Total d.m. (g $plant^{-1}$)	Arka Anamika	155.0				74.8	103.8				75.6
	Parvani Kranti	130.0				84.4	122.9				69.7
				V	T	VxT			V	T	VxT
		SEm	=	9.3	9.3	13.16	SEm	=	3.9	3.9	5.5
		CD (5%)	=	NS	32.2	NS	CD (5%)	=	NS	19.1	NS
Pod d.m.	Arka Anamika	20.0 (13.0)				22.4 (30.0)	37.4 (36.0)				32.1 (43.0)
	Parvani Kranti	17.3 (13.3)				24.9 (29.5)	45.9 (37.4)				31.1 (44.7)
				V	T	VxT			V	T	VxT
		SEm	=	1.0	1.0	1.48	SEm	=	0.72	0.72	1.0
		CD (5%)	=	NS	3.5	5.0	CD (5%)	=	NS	2.5	NS
Root d.m.	Arka Anamika	15.5 (10.0)				6.9 (9.2)	7.2 (7.00)				3.0 (4.0)
	Parvani Kranti	14.3 (11.0)				8.0 (9.5)	9.3 (7.6)				4.2 (6.0)
				V	T	VxT			V	T	VxT
		SEm	=	0.63	0.63	0.89	SEm	=	0.52	0.52	0.52
		CD (5%)	=	NS	NS	NS	CD (5%)	=	NS	1.8	NS

V = variety; T = treatment; VxT = interaction.

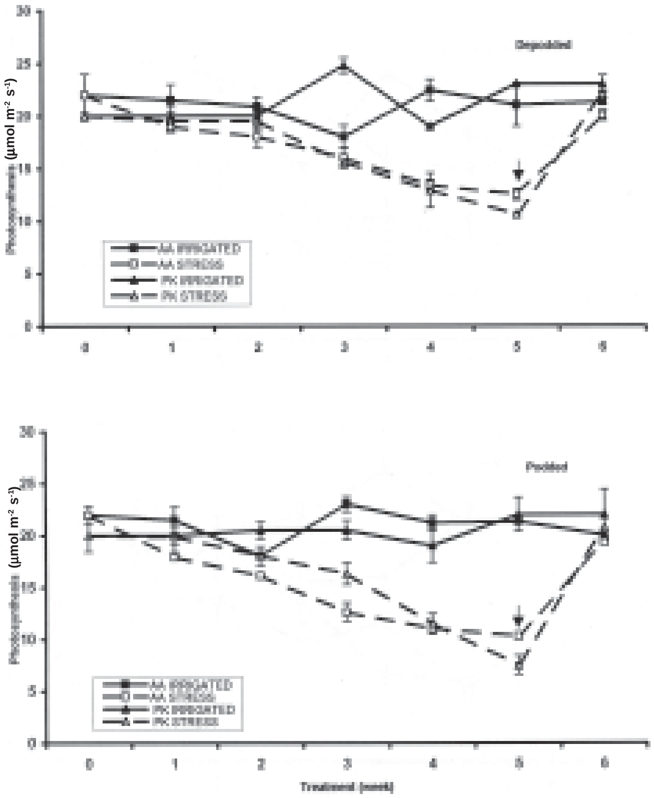

Fig. 1. Photosynthetic rate as affected by water stress in depodded and podded plants of Arka Anamika (AA) and Parvani Kranti (PK). (Arrow indicates release of stress)

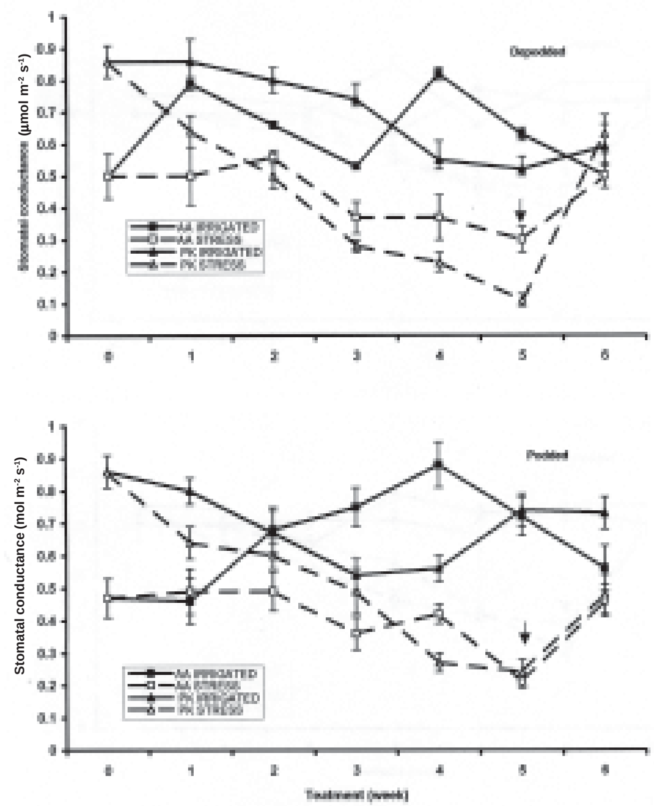

Fig. 2. Stomatal conductance as affected by water stress in depodded and podded plants of Arka Anamika (AA) and Parvani Kranti (PK). (Arrow indicates release of stress)

in depodded and 1.0 to 66 % in podded plants of Parvani Kranti under water stress. The higher reduction in photosynthesis in podded plants may be associated with the limitation on the source as indicated by earlier wilting and substantial reduction in stomatal conductance in the plants where pods were not harvested (podded) in both cultivars. The stomatal conductance was significantly reduced by the incidence of water stress in both cultivars (Fig. 2). In Parvani Kranti, the stomatal conductance reduced sharply in both the group of plants. A reduction of 37 to 52 % in stomatal conductance was found in depodded and 28 to 71 % in podded of Arka Anamika, while it was 25 to 79 % in depodded plants and 20 to 67 % in podded plants of Parvani Kranti. The reduction in stomatal conductance resulted in a considerable reduction in photosynthetic rate in both types of plants under water stress in the present study. However, in a study Ashraf *et al.* (2002) did not find significant relationship between leaf stomatal conductance and photosynthesis under drought in okra. Though, both stomatal and biochemical limitations are known to be responsible for the reduction in photosynthesis (Krieg, 1993, Blum 1988). In other vegetable plants like egg plants and capsicum, stomatal closure was found to be the principal factor in the water stress mediated reduction of photosynthesis (Srinivasarao and Bhatt 1988, 1990).

There was a significant difference between irrigated and stressed plants of depodded and podded plants in both the cultivars (Table 1). Higher value of leaf water potential was found in podded plants of Arka Anamika under irrigated and water stress conditions. However, no significant difference in leaf water potential was found between depodded and podded plants of Parvani Kranti. The presence of fruits has been reported to increase leaf water potential (Downton *et al*. 1987) and has been associated with the maintenance of osmotic adjustment (During and Loveys 1982).

Table 2. Biological yield (total dry matter) and pod dry matter of okra cultivars at final harvest of crop.

Attributes	Cultivar	Depodded					Podded				
		Irrigated				Stressed	Irrigated				Stressed
Total dry matter	Arka Anamika	304.0				159.0	251.6				113.8
(g plant^{-1})	Parvani Kranti	174.0				157.0	185.2				100.5
				V	T	VxT			V	T	VxT
		SEm	=	8.9	8.9	12.6	SEm	=	2.2	2.2	3.2
		CD (5%)	=	31.0	31.0	43.4	CD (5%)	=	7.8	7.8	11.0
Pod dry matter.	Arka Anamika	80.0				36.0	121.0				43.5
(g plant^{-1})	Parvani Kranti	37.0				33.2	91.1				46.8
				V	T	VxT			V	T	VxT
		SEm	=	3.3	3.3	4.6	SEm	=	3.2	3.2	4.5
		CD (5%)	=	11.3	11.3	16.0	CD (5%)	=	11.1	11.1	15.7

V = variety; T = treatment; VxT = interaction.

Biological yield was recorded at the final harvest of the crop after releasing the stress. In podded plants the recovery in stomatal conductance was not on par with irrigated plants after releasing the stress in both cultivars. Though, there was recovery in physiological parameters after releasing the stress, a significant decrease was found at final harvest in total dry matter accumulation in the stressed plants (Table 2). Stress-recovered plants showed reduction in total dymatter from 47 (depodded) to 55% (podded) in Arka Anamika and 10 (depodded) to 46% (podded) in Parvani Kranti at final harvest of crop. This decrease in total dry matter may be due to the considerable decrease in plant growth, photosynthesis and canopy structure as indicated by leaf senescence during water stress. In conclusion, the results indicated that the pod influences the plant responses to water stress as indicated by the differences in leaf area, plant height and carbon exchange characteristics in podded and depodded plants during the water stress.

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