Row Orientation Affects Fruit Yield in Field-Grown Okra

Karan Kaul
Edith C. Greer
Michael J. Kasperbauer
Catherine Mahl

ABSTRACT. Effects of row orientation on fruit yield of okra (*Abelmoschus esculentus* [L.] Moench) were studied. Plants in north-south (N-S) rows produced more fruit than those in east-west (E-W) rows. Amounts of photosynthetic (400-700 nm) and morphogenic light (far-red to red light ratio [FR/R]) received by plants grown in N-S and E-W rows were also determined. The mean amounts of photosynthetic light received by plants grown in E-W and N-S oriented rows were similar. Reflected light received by plants in N-S rows had a higher FR/R ratio than that received by plants in E-W rows. We conclude that row orientation affected yield of okra by influencing the morphogenic light received by plants. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: <getinfo@haworthpressinc.com> Website: <http://www.HaworthPress.com> © 2000 by The Haworth Press, Inc. All rights reserved.]*

KEYWORDS. *Abelmoschus esculentus,* okra, phytochrome, row orientation, yield

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Karan Kaul, Edith C. Greer, and Catherine Mahl are affiliated with the Community Research Service, Kentucky State University, Frankfort, KY 40601.

Michael J. Kasperbauer is affiliated with the USDA-ARS Coastal Plains Research Center, 2611 West Lucas Street, Florence, SC 29501-1241.

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INTRODUCTION

Since the 1940's an enhancement of yields and lowering of costs in horticultural production have been acheived. Both these achievements have depended on petrochemicals for influencing plant growth and development (Brumfield, 1996). During the last decade, interest in sustainable horticultural practices has increased (Brumfield, 1996). Horticultural practices which can result in higher yields of food crops with less dependence on chemicals will be attractive not only to consumers and practitioners of sustainable horticulture but also to limited-resource farmers. The morphogenic effects of far-red (FR) and red (R) light on plants grown under field conditions have been well documented (Kasperbauer 1992, 1994; Kasperbauer and Kaul, 1996). Several developmental responses including photosynthate partitioning among shoots, roots and fruits are regulated by the photoreversible phytochrome system (Kasperbauer 1988). Under field conditions the FR to R light ratio (FR/R) and plant growth can be altered by row orientation (Kasperbauer et al. 1984; Hunt et al. 1985; Kaul and Kasperbauer 1988). Kaul and Kasperbauer (1988) reported that in bush bean (*Phaseolus vulgaris* L.), shoot biomass, fruit yield, and FR/R received were higher in north-south oriented (N-S) rows compared to east-west oriented (E-W) rows. Yields from irrigated soybean (*Glycine max* [L.] Merr.) plants grown in N-S rows have been shown to be usually higher than those grown in E-W rows (Hunt et al. 1985). The above studies demonstrated that leguminous plants with heliotropic leaves reflected more FR and a higher FR/R ratio on the neighboring plants when grown in N-S rows. The higher FR/R light ratio in turn resulted in higher yields. It has also been demonstrated that in plants with non-heliotropic leaves such as corn (*Zea mays*) there was no difference in shoot growth of plants grown in N-S vs. E-W rows (Kasperbauer and Karlen, 1994). Also, there was no difference in the FR/R ratio in light reflected from such non-heliotropic plants grown in N-S rows compared to those grown in E-W rows. Okra (*Abelmoschus esculentus* [L.] Moench) is an important vegetable crop in tropical and subtropical regions of the world. Okra also has heliotropic leaves. The present study was undertaken to determine whether row orientation effects similar to those observed for legumes such as soybean and bush bean will also be observed for okra.

MATERIALS AND METHODS

Okra cv. Perkins seedlings were started in peat pellets (Jiffy Products, Shippagan, New Brunswick, Canada) and grown for six weeks in a greenhouse maintained at day-time and night-time temperatures of 28°C and 21°C, respectively. Seedlings were transplanted into adjacent research plots at the Kentucky State University research farm in N-S or E-W rows on June 10 in year one and May 28 in year two. Rows were 90 cm apart and within each row plants were spaced 45 cm apart. Five rows, each consisting of 14 plants, were used for each treatment. Experimental plots were maintained according to the recommendations of University of Kentucky Cooperative Extension Service (Roberts et al. 1992). Plants were irrigated with trickle irrigation T-tape (T-Systems International, Inc., San Diego, CA). The T-tape had an emitter spacing of 20 cm and was placed on the soil surface so that it was 10 cm away from the row of plants after transplanting.

Amounts of photosynthetic light at 400 to 700 nm and ratios of FR to R photons (FR/R) in the reflected light received by okra plants, grown in the three central rows, were determined using a LI-COR 1800 spectroradiometer (Li-Cor, Inc., Lincoln, NE) with a remote hemispherical cosine-corrected light collector mounted on a 1.5 m fiber optic probe. The light collector was $1.5 \times 1.5 \times 3.5$ cm^3 in dimension and had a 0.6 cm diameter window. Light measurements were taken near the shoot apex of plants, on a cloudless day at 10:00, 13:30, and 17:30 hr four weeks after transplanting. We realize that the spectral composition of incoming as well as reflected light is always changing. Our aim was to determine whether differences in spectral composition of incoming vs. reflected light, shown to exist in canopies of crops such as soybean and bushbean (Hunt et al. 1985; Kaul and Kasperbauer 1988), are also present in canopies of field-grown okra. Therefore, data on reflected light were collected only once. The light collector was oriented to measure incoming light parallel to the soil surface, i.e., light which was being reflected from the surrounding plants. Incoming light was measured from north, south, east, and west. Measurements for all three times were taken in the same sequence. The spectroradiometer was programmed to measure light at 5 nm intervals from 400 to 800 nm. Each time reflected light measurements were taken, incoming sunlight was also measured with the window of the light collector facing toward the sun. The FR/R ratios in reflected light were expressed relative to the FR/R ratio in incoming sunlight at the time of measurement. This approach was used because field plants grow in sunlight with constantly changing spectral properties, and the working hypothesis in this study was that a reflected FR/R ratio higher or lower than that in incoming sunlight should signal different developmental patterns than would be obtained with the FR/R ratio in incoming sunlight. Spectral irradiances at 735 + 5 nm (FR) and 645 + 5 nm (R) were used to calculate the FR/R ratios since 735 nm and 645 nm are the FR and R action peaks in green plants (Kasperbauer et al. 1963).

Yield data were collected from ten central plants in each of the three middle rows of each treatment. Number and weight of fruits from each row were determined separately. Marketable fruits (5 to 11.5 cm in length) were harvested three times every week for approximately 12 weeks starting about 40 days after transplanting. Fruits from all treatments were harvested on the same dates and were counted and weighed.

Data on fruit number and weight were analyzed by analysis of variance (ANOVA) (SAS Institute 1987). Mean separation for data was done by Fisher's Protected Least Significant Difference (LSD) procedure.

RESULTS AND DISCUSSION

Quantity and Quality of Light: Plants in N-S and E-W rows received similar amounts of photosynthetic light (Table 1). Light received by plants in N-S rows had a higher FR/R photon ratio compared to that received by plants in E-W rows (Table 1). A similar difference in FR/R ratio has been reported for soybean and bush bean (Kasperbauer et al. 1984; Kaul and Kasperbauer 1988). Vogelmann and Bjorn (1984) have demonstrated enhancement of the measurable amount of FR through photon scattering within growing leaves. It is therefore likely that the FR/R ratios in light reaching the phytochrome within okra leaves were greater than those reported in Table 1.

Yield Responses: Okra plants showed an effect of row orientation on fruit yield. Significantly higher numbers and total weight of fruit were produced in N-S rows compared to E-W rows (Table 2). The average weight of individual fruit was not influenced by row orientation and remained relatively constant. The average weights per fruit in N-S and E-W rows were 12.38 g and 12.83 g in year one and 11.04 g and 11.21 g in year two, respectively. Thus, the enhancement in yield was due to an increase in the number of fruits produced and was quite likely being brought about, via the phytochrome system, due to the changes in FR/R ratios which brought about differential photosynthate

TABLE 1. Photosynthetic and photomorphogenic light received at the shoot apex of okra plants grown in N-S vs. E-W rows. Light measurements were taken at three times during a cloudless day. Each value is a mean of twelve measurements ± SE.

Light Received at the Shoot Apex	Row Orientation	
	North-South	East-West
Photosynthetic (400-700 nm) (μmol $m^{-2}s^{-1}$)	369 ± 69	377 ± 81
Photomorphogenic (FR/R ratio)	1.11 ± 0.03	1.05 ± 0.02

TABLE 2. Effects of row orientation on number and weight of okra fruits produced per plant during the entire season. Each value is a mean of three groups of ten plants each. In any line, values followed by the same letter are not significantly different at P = 0.05.

Characteristic	Row Orientation	
	North-South	East-West
Fruit Number		
Year one	47 a	40 b
Year two	60 a	53 b
Fruit Weight (g/plant)		
Year one	581.9 a	515.3 b
Year two	662.2 a	594.2 b

partitioning. A similar effect of row orientation on fruit yield has been reported earlier for soybean (Hunt et al. 1985) and bush bean (Kaul and Kasperbauer 1988). Enhancement of fruit yield in response to high FR/R has been reported for other horticultural crops including tomatoes (*Lycopersicon esculentum* Mill.) (Decoteau et al. 1989) and bell peppers (*Capsicum annuum* L.) (Kaul and Kasperbauer 1992). Plants in N-S and E-W rows received similar amounts of photosynthetic light. This indicates that photosynthetic light was not a limiting factor for okra grown in full summer sun in Kentucky. However, fruit production of okra was affected by row orientation (which altered the FR/R ratio in the canopy light) since yields were higher in N-S rows than in E-W rows (Table 2). Plants in N-S rows also received reflected light which had a higher FR/R ratio than reflected light received by plants in E-W rows (Table 1). The results of the present study clearly indicate that yields of okra were enhanced, without any added expense, by growing the plants in N-S rows.

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