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SHORT COMMUNICATION

Cut Flower Productivity and Leaf Area Index of Photosynthesizing Shoots Evaluated by Image Analysis in "Arching" Roses

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Summary

By using image analysis, we could non-destructively estimate leaf area index (LAI) of canopies of photosynthesizing shoots for 'Asami Red' roses trained to "arching" system by several methods when the LAI was less than 4.0. We also studied the relationship between LAI and shoot productivity and found that an LAI of 3.0 to be optimum for the production of "arching" rose plants. Harvesting flowering shoots leaving two five-leaflet leaves effectively increased their number and cumulative fresh weights, compared with harvesting shoots at their point of outgrowth. The necessity of maximizing flowering shoot outgrowth as a sink was discussed .

Key Words: image analysis, leaf area index, photosynthesizing shoot, *Rosa hybrida* L., shoot-bending.

Introduction

To attain high yields of cut rose flowers when using the "arching" (shoot-bending) technique, the architecture of bent "photosynthesizing" shoots must be optimized. In conventionally trained canopies, greater plant densities lead to increased leaf area index (LAI) and dry-weight production per square meter (De Vries and Dubois, 1988). These higher LAIs result in greater stem diameters and weights of basal shoots (Kool and Lenssen, 1997). An excessively high LAI decreased productivity because of shading and increased respiration within the plant canopy (Pien et al., 2001). Our objectives in this study were: 1) to use image analysis for a non-destructive estimate of the LAI of bent-shoot canopies; and 2) to determine the relationships among plant architecture, LAI and shoot productivity.

Materials and Methods

Our wire mesh glasshouse benches (0.93 m × 21 m) were spaced at 140 cm on-center and covered with white, non-woven fabric on which foamed polystyrene beds containing rock wool slabs (7.5 cm × 20 cm × 91 cm) were set. On June 28, uniform, well-rooted single-node cuttings of Rosa hybrida L. cv. Asami Red (Rote Rose) growing on rock wool blocks (5 cm × 5 cm × 5 cm) were placed 10 cm apart on the slabs. The plants were drip-irrigated hourly with the half strength of Enshi standard nutrient solution.

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Training methods

The first shoot that emerged from each plant was bent horizontally toward the southwest on August 23 as a photosynthesizing shoot. Subsequent training method were as follows:

1S: At 90 days intervals, one vigorous basal shoot (70-80 cm long) of each plant was bent as a new photosynthesizing shoot. The bent shoot was removed 90 days after bending. Therefore, each plant in this treatment had only one photosynthesizing shoot at all times.

2S-a: At 45 days intervals, one vigorous basal shoot was bent. The bent shoot was removed 90 days after bending. Therefore, each plant in this treatment had two photosynthesizing shoots at all times.

3S: At 30 days intervals, one vigorous basal shoot was bent. The bent shoot was removed 90 days after bending. Therefore, each plant in this treatment had three photosynthesizing shoots at all times.

TS: Inferior, short and thin basal shoots (below 30 cm long) were bent as photosynthesizing shoots at random intervals. The bent shoots were removed when they died. Therefore, the number of bent shoots was not constant.

From these four training methods described above, the flowering shoots were harvested at the point of outgrowth. Thus, all flowering shoots originated as basal shoots.

2S-b: Photosynthesizing shoots were bent and removed as in 2S-a plants. However, the harvesting method was modified as follows. On harvest of primary basal flowering shoots, they were cut immediately above the 2nd five-leaflet leaf from the base. Secondary flowering shoots which emerged from the leaf axils of the primary shoots were harvested likewise. On harvest of the 3rd flowering shoots which emerged from the secondary shoots, they were cut at the base of the secondary shoot (knuckle-cut method). Subsequent shoot which emerged from the primary shoots was also harvested by knuckle-cut method.

The final architecture of the bent-shoot canopies was accomplished on November 21 for all training methods, and the flowering shoots were harvested from 20 plants per treatment. The date of harvest, stem lengths and fresh weights of the cut flowers were recorded. Flower buds on the photosynthesizing shoots were removed at the pea-bud stage.

Measurement of leaf area by sampling

In preliminary tests, a highly significant regression curve between leaf fresh weight and its leaf area was established by weighing the leaves on numerous developing shoots. Therefore, we sampled the photosynthesizing shoots as the canopies were developing, weighed all their leaves and calculated their leaf area by the regression equation.

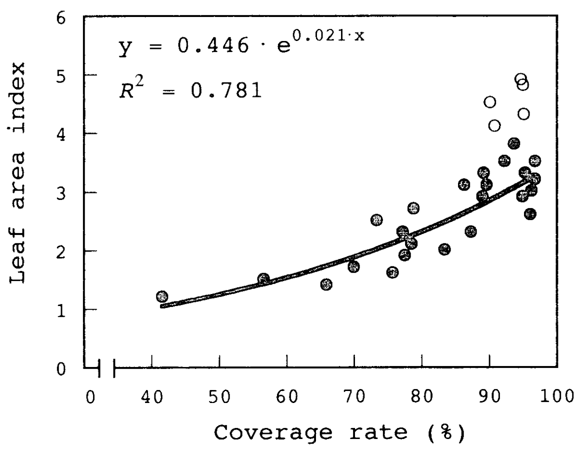

Fig. 1. Relationship between the coverage rate estimated by image analysis and leaf area index (LAI) estimated by leaf sampling in photosynthesizing shoot canopies. The regression equation was derived from data on plants with the LAI <4.0 (closed symbols).

Image analysis

For image analysis, a white frame (70 cm × 50 cm) was superimposed on the canopies of photosynthesizing shoots and photographed weekly at a distance of ca. 130 cm with digital camera. To calculate the rate of coverage by the leaves, the color mode of the images was converted to the black and white mode using an image-processing program on a computer and then the number of black pixels in each image was counted.

Results and Discussion

The relationship between the coverage rate by photosynthesizing leaves determined by image analysis and the estimated values of LAI obtained by leaf sampling (Fig. 1) revealed that as the former increased, so did the latter with increase of their scattering. When the LAI was < 4.0, a significant exponential regression curve ($y=0.446 \cdot e^{0.021x}$, $R^2=0.781$, $P<0.05$) was obtained. Our data from the leaf sampling, LAI for 3S-trained plants was always >4.0 whereas it was <4.0 for 1S, 2S-a and TS plants. Therefore, we conclude that non-destructive estimation of LAI via image analysis is possible for 1S, 2S-a and TS (Fig. 2). For the TS plants, LAI increased gradually from 2.0 in November to 3.0 to 3.5 in March (Fig. 2). The LAI of photosynthesizing shoots for 2S-a plants fluctuated between 2.5 to 3.5 because of bending and removal of the shoots (Fig. 2). The LAI for 1S plants was initially 2.0 and increased to 3.3 in early February but decreased to 1.3 on account of the bending and removal of the shoots on February 19; the LAI subsequently increased gradually (Fig. 2).

The relative number of flowering shoots produced, according to each training method was: TS > 1S > 2S-a > 3S (Table 1). However, the combined number of shoots (i.e., the combination of flowering shoots plus bent shoots: 2 in 1S, 4 in 2S-a, 6 in 3S, and 0.9 in TS) was nearly the same in the 4 treatments. The ranking for cumulative fresh weight of the flowering shoots was also TS > 1S > 2S-a > 3S (Table 1). Cumulative

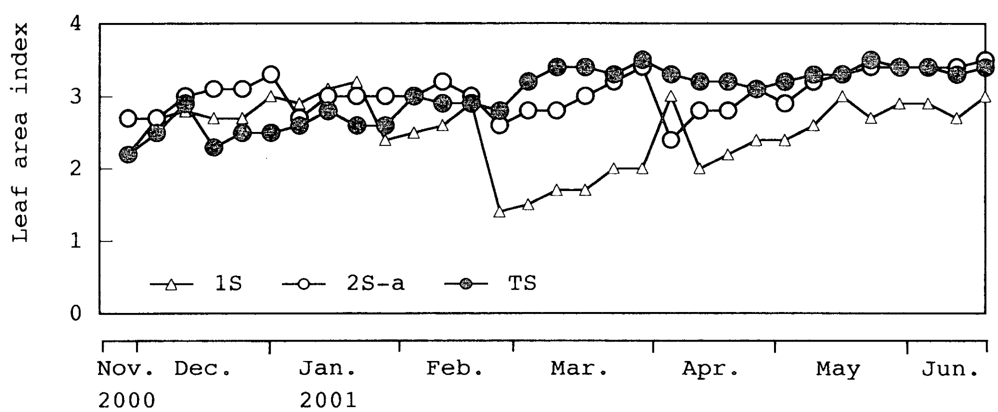

Fig. 2. Seasonal fluctuations in leaf area index estimated by image analysis of the photosynthesizing shoot canopies.

Table 1. Effects of training methods of photosynthesizing shoots on productivity of "arching" rose plants.

Training method	No. of shoots			Cumulative shoot fresh weight (g)		
	Flowering (a)	Bent (b)	Combined (a+b)	Flowering (c)	Bent[z] (d)	Combined (c+d)
1S	10.4 ± 0.7[y]	2.0	12.4	401 ± 28	80	481
2S－a	9.3 ± 0.6	4.0	13.3	369 ± 22	160	529
3S	6.4 ± 0.5	6.0	12.4	283 ± 28	240	523
TS	12.4 ± 0.6	0.9	13.3	547 ± 18	11	558
2S－b	15.1 ± 0.6	4.0	19.1	586 ± 18	160	746

Data were taken from December 17, 2000 to June 14, 2001.
[z] Assuming 40 g per bent shoot for 1S, 2S－a, 2S－b and 3S methods; or 12 g per bent shoot for TS method.
[y] Mean ± SE.

combined shoot fresh weights were also calculated by adding weights of the bent shoots (assuming 40 g per shoot for 1S, 2S－a and 3S plants; or 12 g per shoot for TS plants, from our sampling data) to those of the flowering shoots. The ranking for cumulative combined shoot fresh weights was TS ≈ 2S－a ≈ 3S > 1S.

The cumulative combined shoot fresh weight for 2S－a plants with an average LAI of 3.0 was the same as that for the 3S plants with larger LAI. This fact indicates that an LAI of 3.0 approximately the optimum for production of "Arching" roses. This optimum LAI of 3.0 agrees with that estimated mathematically by Pien et al.(2001). For 2S－b plants, in which the flowering shoots were harvested at the upper node, the yield was higher than that from the 2S－a plants; the cumulative combined shoot fresh weight was also higher in the former than in the latter (Table 1).

The conventional "arching" rose in which the flowering shoots originate from basal shoots results in longer and heavier flowering shoots but fewer cut flowers (Ohkawa and Suematsu, 1999; Tjosvold, 2001). Marcelis－van Acker (1993) reported that basal shoots of roses originate from axillary buds and not from adventitious buds. The axillary bud inhibition in rose increases towards the base of the shoot (Dambre et al., 2000); thus, the axillary buds on upper nodes dominate. Harvesting flowering shoots leaving one or two of the five－leaflet leaves effectively induces the subsequent emergence of flowering shoots from the leaf axils (Dambre et al., 2000; Hoog et al., 2001). We found that the 2S－b plants produced most cut flowers with the heaviest combined shoot fresh weights. Therefore, to improve the productivity of cut－roses, we need to seek means to maximize the flowering shoots as a sink for photosynthates.

Literature Cited

Dambre, P., L. Blindeman and M. C. Van Labeke. 2000. Effect of planting density and harvesting method on rose flower production. Acta Hortic. 513: 129－135.

De Vries, D. P. and L. A. M. Dubois. 1988. Effects of plant density on root and shoot characters of one－season－old *Rosa canina* 'Inermis' seedling. Gartenbauwissenshaft 53: 117－121.

Hoog, J. D. Jr., M. Warmenhoven, B. Eveleens－Claark, N. Van Mourik and N. Marissen. 2001. Effects of plant density, harvest methods and bending of branches on the production and quality of roses. Acta Hortic. 547: 311－317.

Kool, M. T. N. and E. F. A. Lenssen. 1997. Basal－shoot formation in young rose plants: effects of bending practice and plant density. J. Hort. Sci. 72: 635－644.

Marcelis－van Acker, C. A. M. 1993. Morphological study of the formation and development of basal shoots in roses. Scientia Hortic. 54: 143－152.

Ohkawa, K. and M. Suematsu. 1999. Arching cultivation techniques for growing cut－roses. Acta Hortic. 482: 47－51.

Pien, H., E. Bobelyn, R. Lemeur and M. C. Van Labeke. 2001. Optimizing LAI in bent rose shoots. Acta Hortic. 547: 319－327.

Tjosvold, S. A. 2001. Effect of bending on production and quality of commercial greenhouse roses in field soil. Acta Hortic. 547: 299－301.

アーチング栽培バラにおける光合成専用枝群落の画像解析による葉面積指数評価と切り花生産性

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摘　要

いくつかの仕立て方によりアーチング栽培を行ったバラの光合成専用枝の葉面積指数は，4.0以下の範囲となる場合，画像解析により非破壊的に評価することができた．また，葉面積指数とシュートの生産性との関連を検討したところ，3.0前後の光合成専用枝の葉面積指数がアーチング栽培バラの生産に最適であると結論された．2枚の5枚葉を残して開花枝を収穫すると，基部で収穫するよりも開花枝の発生数，総新鮮重が増加した．このことから，シンクとしての開花枝の発生促進の重要性について考察した．

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