Final Report to Roses Inc and the Joseph Hill Memorial Foundation

Development of optimal rose canopy management strategies for rose growers: "Bending" versus traditional production

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Summary of progress

This report describes the results from our investigation into optimal strategies for producing roses. Bending and hydroponics were investigated.

Traditional cut-flower rose production involves growing plants in the ground and training the canopy vertically as a hedge. In recent years growers have begun to bend various branches down and to grow plants in hydroponics, rather than in the ground. Our objective in this study was to explore whether these methods were significant improvements over traditional methods and how these new methods could be used more optimally.

Thus we compared shoot-bending and hydroponic production with conventional production over the time period from September 1997 to August 1999. We tracked the number of the harvested flowering shoots and stem length to determine crop productivity and quality. The plants under the shoot-bending regime produced significantly longer stems than the ones under the non-bending regime. However, production counts under bending were lower (for the variety 'Fire and Ice') or the same (for 'Kardinal').

We evaluated the economic advantage of the trade-off of production counts versus quality (stem length). With 'Fire and Ice' we found that even though longer stem length resulted from the shoot-bending, it did not compensate for the fact that there were fewer harvested flowering shoots. In fact, growers who can sell all of the shortest grade or don't get a premium for the longest grade, are better off bending only stems that are obviously blind or shorter than the shortest grade. With Kardinal there was no advantage nor disadvantage to bending, regardless of the grower's economic situation. In general, if a grower can only sell long stems and has to discard weak stems and shorter grades, then bending should be applied so as to convert all unsalable shorter stems into longer grades. Growers that are able to sell some amount of shorter stems, are better off to bend only the portion of the crop that would not be salable and actively produce as much short material as they can sell.

We found only a slight advantage of hydroponics over production in raised beds with tensiometer-based irrigation control and only for one variety. Although no trials were run with in-ground roses, previous experience suggests that the methods used in this study (i.e. soil-less

culture with tight irrigation control) are superior to in-ground production.

Introduction

Prior to 1995 virtually all rose production in the US involved growing plants in the ground. Containerized rose production was generally limited to research centers and a few growers who wanted the flexibility to move plants around for one reason or another. Meanwhile in Europe, a number of rose growers were growing in rockwool and experimenting with various forms of gravel-culture. Some North American growers adopted this but found it hard to live without the buffer that the soil provides in irrigation and fertilization management; thus few other American growers followed suit. One of the main drawbacks was that the rockwool slabs only lasted a few years and American growers had difficulty disposing of the spent rockwool. Around 1995 various growers in Europe began growing “hydroponically”. Although rockwool production is a form of hydroponics, the term (as it is used today) refers to production in a container where the bottom 2 inches consists of a reservoir of nutrient solution and the space above that is composed of coconut coir, suspended above the reservoir using a coarse expanded clay product in the bottom of the container. Irrigation is generally done several times per day. Currently excess irrigation solution leaving the container is generally discarded.

At the same time a new canopy management technique became fashionable among some growers in Europe and Japan. This method involved bending portions of the plant over. The plant responds to this by slowing the growth of anything that is bent down and forcing buds to break. Breaking buds on the main part of the plant can grow and elongate in an uninhibited fashion; buds on the bent part are strongly inhibited and generally do not elongate; some leaf growth occurs on the bent side, but not much else.

Initially this method was used to regenerate plants (i.e. get new bottom-breaks) by “arching” entire hedges over. As such it was a replacement for the heavy pruning that was generally used in the late spring to reduce hedge heights. In this method, pruning is still done, but it is done after the bottom-breaks have been generated. This is not an easy procedure since care has to be taken not to damage the plants or new buds. Thus this methods is not widely used as it is very labor-intensive.

When producing plants in hydroponics, growers generally find that one cannot generate a hedge because shoots which emerge from the plants some distance above the container, tend to be weak. With the onset of the use of hydroponics, these growers also began bending down anything that seemed to be weak. The key to success was to bend early, before the plant invested a lot of resources growing the unproductive shoot. The difficulty lay in determining early on which shoots were destined to be weak. There were numerous questions about the practice and how to optimize it.

In this study we sought to determine the optimal strategy for bending by comparing production with non-bent plants, and by contrasting hydroponic production with non-hydroponics. Our initial intent was to grow non-hydroponic plants in the ground; however this proved impossible since it was logistically impossible to construct independent randomized samples. Thus we compared the hydroponic production to production in container medium UCMix.

Materials and Methods

The set-up of the research plots at UCDavis (Fig 1) consisting of two varieties of cut-flower roses ('Kardinal' and 'Fire and Ice') growing in either hydroponic and non-hydroponic production. The hydroponic production system consists of plants growing in buckets filled partially with hydrocorn (a 2-inch layer) and topped off with coconut coir. It was configured and operated in the same way as was being tried in many commercial rose greenhouses in California. The hydroponics system was donated to the project by Systems USA (Watsonville, CA)

The non-hydroponic production system was also set up. Originally we had planned to plant roses in the ground, but questionable soil quality and the inability to later move such plants to modify the growing density (and LAI) forced us to plant the rose plants in wooden boxes (dimension of 45x 90 inches, 12 inches deep) filled with the UC Mix.

Of these, some plants were produced as bent plants; others were grown conventionally

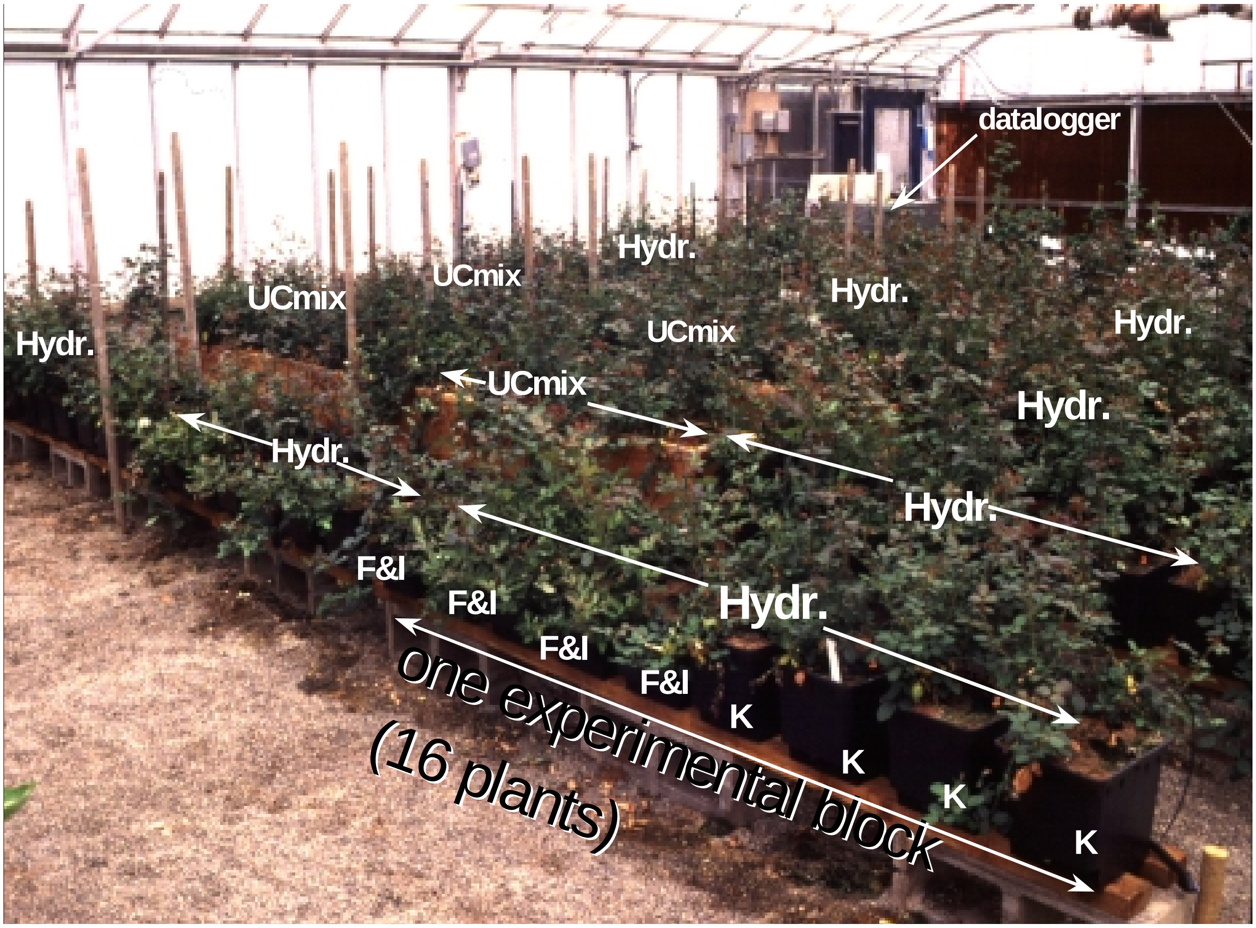
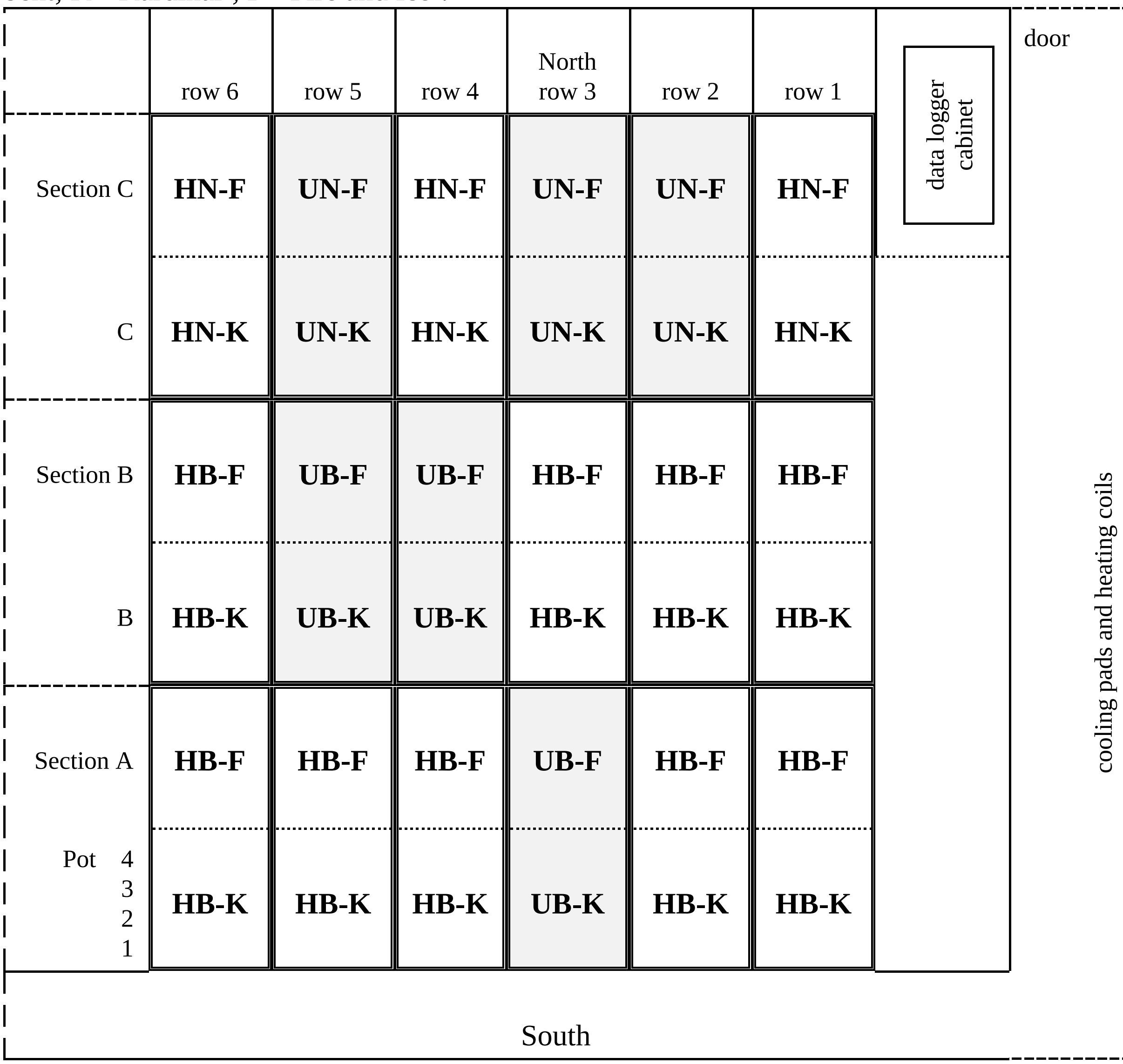


Figure 1 Set-up of experiment at UCDavis

(without bending). It was decided not to randomize this treatment since setting up a group of conventionally trained plants among groups of bent plants would result in blockage of air movement and shading, thus confounding the experiment. The plants were placed in a randomized design within these two sections (Fig 2) in units of either one such box or 8 buckets, each comprising 1 group of 16 plants; of these the 8 northern plants were ‘Fire and Ice’; and the southern 8 plants were ‘Kardinal’. Thus the layout of treatments and varieties was such that all the non-bent plants are on the north side of the trial, and the bent plants on the south side.

The nutrient solution used for all plants was a modified (half-strength) Hoagland solution. The moisture status of the root media was tracked using tensiometers hooked up to a computerized data-logging system. The plants in the hydroponic system receive an application of irrigation solution four times a day. The remaining plants are controlled by a tensiometer-based

Figure 2. Lay-out of the experiment in the greenhouse: Each cell in diagram represents 8 plants in either 4 buckets or half of a box. H=hydroponics, U= UC Mix in boxes; B=bent, N=non-bent; K='Kardinal', F='Fire and Ice'.



irrigation system which maintained the moisture tension between 1 and 3 kPa.

Data collection

Environmental factors such as light intensity (photosynthetically active radiation), temperature, carbon dioxide concentration, and root media moisture tension were monitored using a data logger.

We did have one boiler outage in December of 1998 which caused temperatures to dip below 15C, but we were able to keep the damage to a minimum.

The number and quality of each harvested flowering shoot was recorded during the entire experimental period. This resulted in a database of almost 15,000 shoot observations, allowing us to compare productivity of the treatments at any resolution over time (daily, weekly, monthly, etc) and for any group of plants.

Economic value calculation:

The length of the stems is the primary indicator for value on the market. Thus we developed an index to allow us to estimate the economic value of every stem that harvested during our experiment. This index is calculated by the formula:

$$V1 = \begin{cases} 0 & \ldots \text{if SL} < 25 \\ 0.020 + 0.0043 \times (\text{SL} - 25) & \ldots \text{if SL} \geq 25 \end{cases}$$

where SL is the stem length (cm) and V1 is the value. It should be noted that this values 14", 18", 22" and 26" stems at $0.35, $0.39, $0.44, and $0.48, respectively. This index is intended as a method for accounting for stem quality in our analysis, rather than actually assessing dollar values; it only resembles actual dollar values if the market is stable and the actual dollar returns are always like those modeled in the equation above. Because some growers reported frequent inability to sell all their weak stems, we calculated another index V2, where all the stems shorter than 40 cm (16 inches) were discounted 50%. We also calculated an index V3 from V1 for the case where the market rewards long stems with double the value for stems longer than 60 cm (24 inches). We also calculated index V4 which applies both the short-stem discount as well as the long-stem bonus to V1.

The resulting index values for each stem were analyzed to see if there are differences among the treatments. It should be noted that we have no other economic information (e.g. differences in input costs between the different systems), thus our results assume that these are the same regardless of bending method or hydroponics.

Results and Discussion

Average daily light (PAR) and temperatures within the greenhouse showed a cyclical pattern over the year with lows in the winter and highs in the summer (top portions of Figures 3 or 4). Generally temperatures were kept within reasonable ranges averaging: 17 - 20 C in the winter and 20 to 25C in the summer. Light levels were significantly higher in the summer than winter. During the summer of 1998 whitewash was applied to the greenhouse, while during the summer of 1999 we had whitewash only on glazing that was not over the production study (shading our plants only after about 1 p.m. in the afternoon, and only for part of the summer). No supplemental lighting was used in this project.

Monthly patterns

The two varieties showed substantial differences in how they responded to the various treatments, both month-to-month and seasonally. Both ‘Kardinal’ and ‘Fire and Ice’ are long stem roses with moderately large flower heads. ‘Kardinal’ was selected because it is grown by a large number of growers, both in-ground and hydroponically. ‘Fire and Ice’ was also popular at the time of the experiment and the propagator (Everbloom, Carpinteria, CA) contributed these to the project. It was primarily selected, because of it’s popularity and high production potential.

Once the plants were established (Sep 97) stem lengths and counts varied seasonally; the degree to which differences were apparent among treatment also varied seasonally as well as between the first and second year. This suggest that care must be taken in adopting production practices described below for different varieties; growers would do well to change any existing production practices gradually and to monitor the effect carefully, and separately for each variety.

One of the major features of the production data for both ‘Kardinal’ and ‘Fire and Ice’ was the substantial dip in all variables (stem length, stem counts, and value) during the winter of 1998/99. Although the light levels were clearly lower during this period than other periods, that does not account for the degree to which production is depressed. In fact, light levels in the previous winter were lower without the level of production depression we note during Dec 98 to Feb 99. The reason for this can be attributed to a widespread defoliation of plants (particularly of Kardinal) as the result of a phytotoxic response of volatilized sulfur several weeks after a pesticide spray (SunSpray, Micogen) during Nov 98. The impact on the plants was very dramatic with both varieties dropping virtually all leaves that were on the plant at the time of the

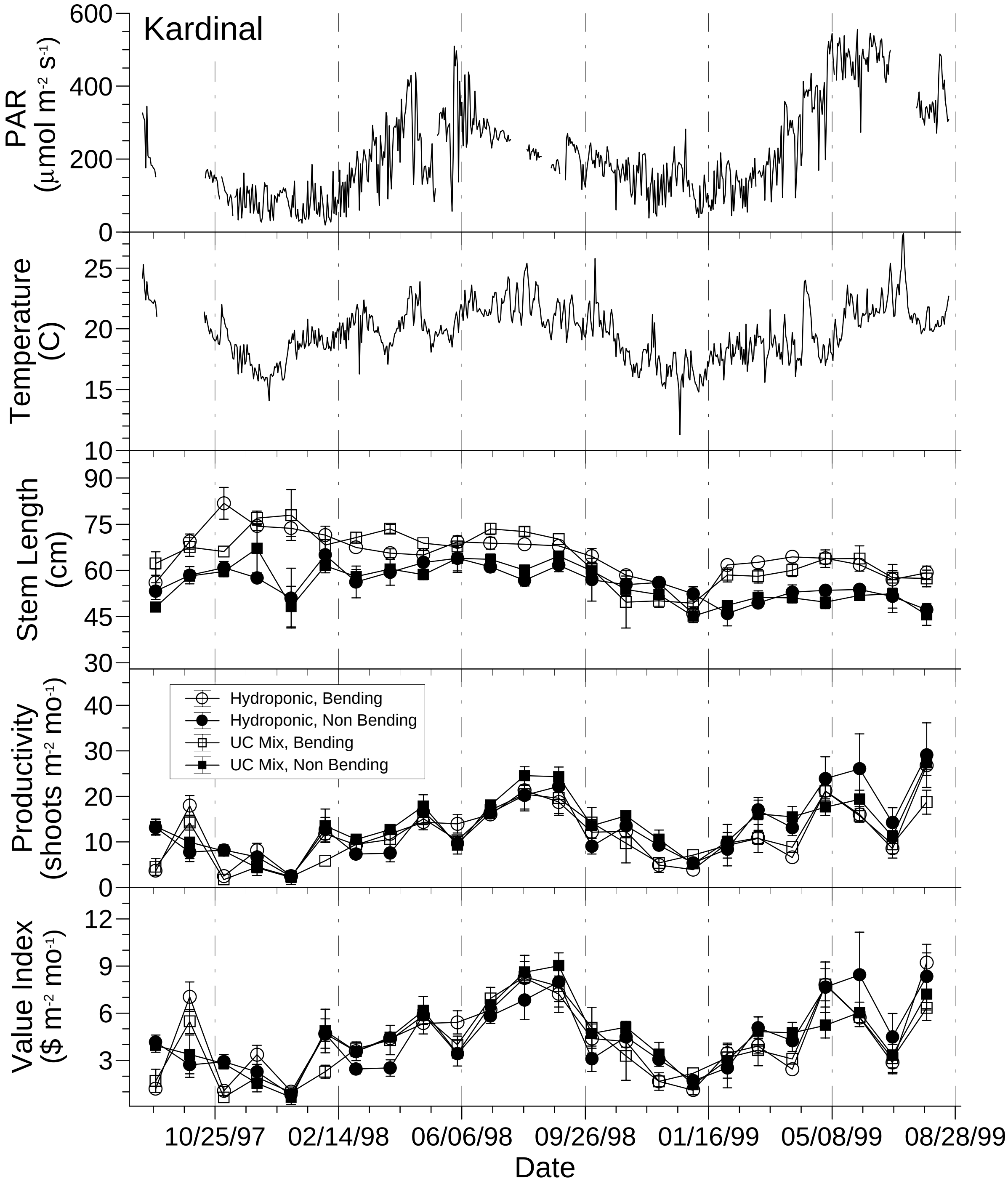


Figure 3 Weekly PAR and temperature averages and monthly production data for 'Kardinal'.

spray application (3 weeks earlier). While the plants appeared to recover from this shock within a few weeks, the production variables demonstrate the effect for several months (well past Valentines day 1999). It should be noted that the pesticide label addressed the phytotoxic effect

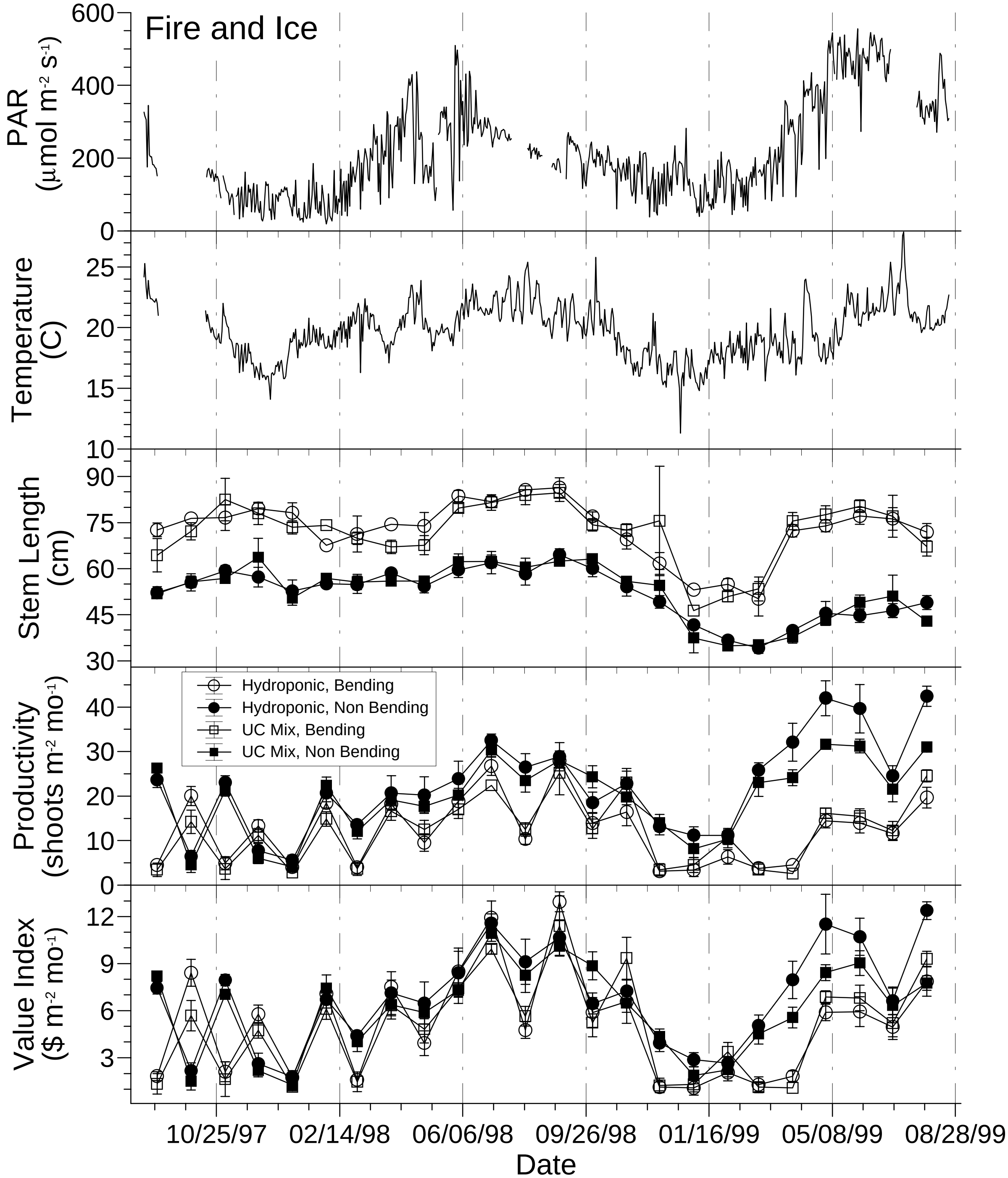


Figure 4 Weekly PAR and temperature averages and monthly production data for 'Fire and Ice'.

that we observed, but the phytotoxic interactions with sulfur was supposedly a concern only for a brief time after application.

Stem quality (Stem length):

The production pattern for plants in hydroponics (Fig 3 and 4, circles) versus plants growing under tensiometer-based irrigation in UCMix (Fig 3 and 4, squares), were virtually identical. While some minor differences occurred in some months, virtually all monthly averages show no significant differences between hydroponic and non-hydroponic production. This suggests that while hydroponics is clearly a useful production technique, one can do equally well with raised beds of highly amended medium under tensiometer-based irrigation control.

For both 'Kardinal' and 'Fire and Ice' there are dramatic differences in stem length between bending (Fig 3 and 4, open symbols) and non-bending (Fig 3 and 4, closed symbols) during all months except the months when the plants were experiencing significant defoliation. Healthy 'Kardinal' plants produced shoots that were typically 10-15 cm longer in the bent treatments. 'Fire and Ice' was even more dramatic, producing stems that were 20-25 cm longer.

Production counts:

Early on, production counts on the plants in the various treatments were somewhat out of synch with flushes of harvestable stem in one treatment coming at different times as flushes in other treatments. Once all plants received a pinch to time production for Valentine's day 1998, the various treatments became synchronized and all showed a strong production count for Valentine's day followed by a low count after that. From then on the average counts for the bent plants were either the same as the non-bent plants, or lower. In 'Kardinal' the differences were minimal, while for 'Fire and Ice' stem counts for the bent plants were always significantly lower. During the second year, 'Fire and Ice' production in the non-bent treatment was almost double that of the bent plants. However, in the same time frame, the stems of in the bent treatment was much longer.

Value Index:

Clearly the effect that growers wish to achieve (both: high counts and long stems) is not achieved by any one treatment. Thus one cannot select an optimal practice without consideration of trade-offs. Such trade-offs need to be evaluated with respect to some objective. While each growers would probably prefer to see the objective to be optimization of profits, this is virtually impossible as each grower has a differing array of expenditures and market conditions. The value index used in this study provides a method only for making a rough assessment of profitability.

The value index (V1) described above was used to estimate a financial value for each harvested stem based on the market value at one California flower market on one day in November 1998. Because the index is static, results from its use in this report do not account for variation in value over the year or for holidays. As formulated here, the higher the value index, the higher the gross financial return to the grower.

The monthly index values followed the productivity patterns much more than the stem length pattern, suggesting that growers who fanatically push for the longest stem length at all costs, are missing the big picture. Profitability is more linked to production counts than stem length.

For 'Kardinal' there are very small value differences month to month, while for 'Fire and Ice' dramatic differences exist in some months. But the value index from treatments where plants were not bent is typically higher. This is at odds with many growers viewpoints.

Another thing that emerges from these results is that it is dangerous to draw conclusions about roses from data for periods of time of less than a few months. This is underscored by our study as our earlier reports (prior to January 1999) drew some different conclusions. This can also be seen from the fact that patterns during the second year are very different from the first year. This fact is particularly important to those who make decisions regarding rose production research: clearly a multi-year approach is needed whenever testing rose production practices under conditions that emulate commercial production.

Table 1. Number of flowering shoots per m^2, stem length and value index from September 1997 to August 1999. Value index was estimated using equation 1.

Cultivar	Culture	Canopy Bending	Shoots per m^2	Stem Length (cm)	Value Index ($\$/m^2$)			
					V1	V2	V3	V4
Kardinal	Hydro.	Yes	284 a	64.9 a	105 a	104 a	175 a	175 a
		No	320 a	56.1 b	106 a	99 a	153 a	147 a
	UC Mix	Yes	266 a	65.1 a	99 a	98 a	164 a	163 a
		No	331 a	55.7 b	108 a	102 a	156 a	150 a
Fire & Ice	Hydro.	Yes	292 c	76.1 a	123 b	122 b	225 a	225 a
		No	537 a	51.6 b	164 a	147 a	222 a	207 ab
	UC Mix	Yes	289 c	73.9 a	119 b	118 b	210 a	209 ab
		No	475 b	52.4 b	146 a	131 ab	200 a	188 b

Numbers with the same letter within a column for each variety are not significantly different (Tukey's studentized range test with $p < 0.05$)

Cumulative results

The cumulative production over the whole experimental period for the entire plot showed that the patterns described above also held true in summary over the whole time frame (Table 1). The practice of shoot-bending resulted in longer stems than conventional canopy management (non-bending regime) in both cultivars over the course of experiment in both the hydroponics as well as in the UC mix.

The number of harvested shoots per m^2 showed some dramatic differences for 'Fire and Ice', but not for 'Kardinal'. 'Fire and Ice' produced far fewer harvestable flowering shoots under bending than in conventional (non-bending) production. No differences were found in the number of harvested shoots in 'Kardinal' among any of the treatments. This suggests that shoot-bending for 'Kardinal'does not significantly reduce the flower production while the stem length (yardstick for flower quality) still can be improved markedly through bending.

The value index V1 was significantly lower for 'Fire and Ice' in the bent treatments than in the non-bent treatment. This indicates that for Fire and Ice the improved quality (longer stems) gained from bending does not offset the reduced number of stems; in fact the economics are substantially in favor of not bending. There was no significant difference between growing 'Fire and Ice' in hydroponics versus UC Mix. For Kardinal the were no significant differences in value, suggesting that the system with the lowest input costs will be the most profitable for this variety.

In discussions with growers we found that some felt that there were many times when they could not sell the lowest grade roses at all. For these growers we calculated index V2 which reduces V1 by 50% for each stem shorter than 16 inches (stem shorter than 12 inches are always valued at zero). This is not unlike having to discard half of the shortest stems. In this situation the conclusion is very similar: no differences for 'Kardinal', and for 'Fire and Ice' bending does not yield greater financial value; the greatest return is still from the plants that were not bent.

Other growers indicated that they received a premium for the longest stems grown in hydroponics. To reflect this opportunity we calculated another index, V3, where we doubled the V1 value for any stem longer than 24 inches. While this is likely to be extreme, it does allow us to see if that changes the results. For V3 there were no significant differences between any of the treatments.

Index V4 was calculated by applying the 50% discount to V1 for stems shorter than 16 inches and doubling the V1 value for stem longer than 24 inches. For 'Kardinal' this did not change anything: there were no significant differences between treatments. For 'Fire and Ice' there are no significant differences between bending or not bending.

Conclusions

We found that shoot-bending significantly reduces flower production and that any improvement in economic return will depend on how dramatically the stem length is improved by the shoot-bending practice. In both 'Kardinal' and 'Fire and Ice', bending did not result in greater economic benefit.

In comparison with plants grown in UC mix in raised beds, hydroponics offered little advantage. There was no significant difference in the number of flowering shoots harvested in 'Fire and Ice' between hydroponic and non-hydroponic cultures in the bending treatment. Unbent 'Fire and Ice' plants did produce greater number of shoots in hydroponics.

Using the value calculation, we found that bending in ‘Fire and Ice’ resulted in less estimated economic value despite improved flower stem lengths. However, the improvement in stem length will, at the most, compensate for the reduction in flower number. In ‘Kardinal’ however, we saw no differences in economic value between any of the treatments. Bending did not result in greater economic value even with the most extreme value calculation.

Thus what we learn here is that indiscriminate bending of anything that might turn out to be a short rose stem is not likely to be optimal for most growers. However, bending can be a powerful tool, but not necessarily on all rose varieties. In some sense, growers should bend to such a level as to produce as many short stems as they can sell. Whenever they have to toss or heavily discount the shortest grade, then more bending would have been advised some weeks prior to that. It is, of course, very difficult to know this at the time that it needs to happen.

While, in general, there were no major advantages to hydroponics over raised-bed production, it should be noted that we did not compare hydroponics with in-ground production. Our tensiometer-based irrigation system was able to do as well in most cases; and we have shown in the past that this type of irrigation method can result in significantly higher production that in-ground production. Thus it is quite likely that most growers can expect greater productivity with one of the systems described here, than conventional, in-ground rose hedges. The deciding factor would probably be largely the differences in installation and maintenance costs of the different systems.