THE EFFECT OF CYCLIC LIGHTING AND GROWTH REGULATORS ON THE ROOTING OF *RHUS LANCEA* CUTTINGS

by

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INTRODUCTION

The *Rhus lancea* tree, commonly known as the African Sumac, plays an important part in southwest landscape design and as a low type windbreak. The growth habit of this evergreen tree is willowlike in appearance. Its spreading habit provides dense shade for the home yard and a thick barrier for windbreak purposes in agricultural areas. *Rhus lancea* is especially suited to southern Arizona's climate and soil conditions as evidenced by its widespread use. It is alkali tolerant and drought resistant as might be expected due to its origin.

According to Burkhart (4), the tree was observed in its native habitat by Dr. Homer L. Shantz, botanist and former President of the University of Arizona. In 1919 he collected seed at Wonderboom, North Pretoria, South Africa. Trees grown from this seed were established at Chino, California and two of them were transplanted to the Boyce Thompson Southwestern Arboretum near Superior, Arizona for trial purposes. When Dr. Shantz became president of the University of Arizona in 1928 he had one of the trees moved from the Arboretum to the University campus and replanted east of Maricopa Hall. In 1941 two trees grown at Chino were transplanted bareroot to the lawn in front of the University of Arizona library (12) where they are presently growing. These are the two trees illustrated in the photographs on page 2.

Since the introduction of the *Rhus lancea* into Arizona it has been propagated from seed by nurserymen. The Soil Conservation Nursery,

Fig. 1. The male Rhus lancea tree growing in the lawn in front of the University of Arizona library.

Fig. 2. The female Rhus lancea tree growing in the lawn in front of the University of Arizona library.

formerly located near Tucson, propagated many thousand Rhus lancea by seed for windbreak use in the southwest. The dioecious nature of Rhus lancea results in both the desirable male and the undesirable female tree when grown from seed. The trees bloom in January and February and the resultant berries which are produced on the female tree cause the branches to bend due to the excess weight of the seed. Limb breakage is prevented by stripping the seed or by pruning the fruiting limbs. The beauty and function of the female tree is often destroyed by pruning for seed removal. Figures 1 and 2 show the difference in size and shape of the male and female trees located in the front lawn of the University of Arizona library. Both photographs were taken at the same distance from the respective trees and the difference in their size and shape is illustrated. The undesirable fruiting habit of the female tree was the reason for seeking a method of obtaining new plants by vegetative means.

A search of the literature did not disclose any previous work with vegetative propagation of this species. In the spring of 1962, the Horticulture Department Plant Propagation class observed a number of rooted Rhus lancea cuttings in their plots.

In the summer of 1962 preliminary work was initiated by the author to determine the ability of Rhus lancea to root from stem cuttings. The cutting material was obtained from a male tree located just east of Maricopa Hall on the University campus. Untreated cuttings of approximately 4 to 6 inches in length were placed in flats containing perlite and placed under mist. The cuttings were separated into three groups according to the age of the stem from which they were made. It has been shown, as pointed out by Adriance and Brison (1), that the ability of a cutting to initiate roots depends upon the age of the wood for a particular species. There seemed to be some disagreement between authorities as to the names and definitions which should be applied to the various ages of wood from which cuttings are made. Of the four references on plant propagation which were reviewed (8, 11, 16, 18), the names and a slight modification of the definitions given by Mahlstede and Haber (11) best explain the types of stem cuttings available from Rhus lancea.

Greenwood: Refers to cuttings taken from woody plants prior to lignification when tissues are still relatively soft. These are available only during the growing season. These cuttings are obtained from the tip 4 to 6 inches of the branch.

Firmwood: Differs from greenwood in the degree of maturity. Generally collected later in the season when at least the lower portion of the stem becomes lignified. They are capable of being bent without breaking, and have leaves.

Hardwood: Cutting is lignified throughout its entire length. It snaps when bent. Usually no leaves present except on laterial branches.

Work done by Calma and Galston (5) with herbaceous cuttings of Coleus showed that leaves allowed to remain on cuttings stimulated more vigorous rooting. Zimmerman (19), working with greenwood cuttings, found that the amount of leaf area on cuttings had a direct effect on the rate of root growth. These findings are in accord with the observations of Mahlstede and Haber (11) who found that tissues of greenwood cuttings have little stored food reserves and therefore rooting depends upon photosynthetic activity of the cuttings. In accord with this information, leaves were removed only from that portion of the cutting which was inserted in the rooting media.

The basal cut on the Rhus lancea cuttings was made just below a node. There is disagreement between research workers in plant propagation as to whether it is best to make the basal cut between nodes (14) or just below a node (9). The arguments given by Kemp (9) seem to be the soundest. He stated that better healing of the cut ends was obtained when the cut was made just below the node rather than through the node. In hardwood particularly, nodal cuttings are more desirable since the pith is usually absent or at any rate is less prominent at the node, and just below the node there is already the additional meristem at the junction of the leaf trace and the stem vascular system. He also stated that when internode cuttings give better rooting, it is usually in those plants which are in the easy to root category.

Due to the mist having been turned off by persons unknown, all of the cuttings in the preliminary experiment died. When the cuttings were examined it was found that several had rooted. Rooting appeared to have been most rapid on the greenwood cuttings. Cuttings of pyracantha which were in flats on the same bench and had been made at the same time were not rooted and were also dead. Pyracantha is generally considered fairly easy to root.

In view of the fact that some cuttings of Rhus lancea rooted in the spring and again in the summer of 1962 it was decided to carry on further rooting studies and to include some factors which might influence rooting.

Waxman (15) reported that cuttings of Weigela and Cornus florida produced twice as many roots per cutting when subjected to a one hour exposure of low-intensity incandescent light given in the middle of the dark period, as compared to cuttings not receiving the light break. He concluded that this photoperiodic treatment influenced the number of roots produced on leafy cuttings. Snyder (13) found no significant effect of photoperiodic treatment on the rooting of cuttings of Taxus cuspedata. Similarly Lanphear and Meahl (10) working with selected woody ornamentals found that long photoperiods had a different effect on rooting in winter as compared to fall. The effect also varied with the species. Since it had been shown that lengthening the photoperiod improves the rooting of some woody species it was decided to compare the rooting of Rhus lancea cuttings under an extended photoperiod and under the natural photoperiod.

Another factor which was chosen for investigation was the effect of treating the cuttings with growth regulator solutions before placing them in the rooting media. The growth regulator substances used were indolebutyric acid (IBA) and naphthaleneacetic acid (NAA). According to Audus (2) IBA and NAA are superior to other growth regulators in stimulating rooting due to their greater chemical stability and their low mobility in the plant. He indicated that in many instances a greater number of roots resulted from the combination of IBA and NAA than from either substance alone.

On December 20, 1962 blossoms were taken from the two trees in front of the library and the tree east of Maricopa Hall. Upon microscopic observation it was determined that the tree on the east side of the library bore only pistillate flowers while the tree on the west of the library and the one east of Maricopa Hall bore only staminate flowers. All cutting material for the two subsequent experiments was taken from the tree east of Maricopa Hall which had been identified as a male tree.

MATERIALS AND METHODS

The experiments were conducted on the west bench in the Horticulture greenhouse. The north end of this bench was equipped with three banks of fluorescent lights, suspended over the bench. It has been shown by several experiments (3, 6, 7, 17) that cyclic lighting will invoke the same response in plants which are sensitive to day length as will lighting for a continuous period of time. Cyclic lighting consists of alternating light and dark periods. Effective cyclic length depends on the ratio of red to far red energies in the light source. For this reason light from ruby-red, incandescent-filament, and fluorescent lamps is about equally effective in 15-minute cycles. The effectiveness of ruby-red to invoke photoperiodic response fails in 30-minute cycles and of incandescent-filament in 60-minute cycles, whereas that of fluorescent remains high in longer cycles (3). In some experiments (6) a photoperiodic response was invoked by lighting the plants intermittently only 5 per cent of the time during the number of hours which were previously continuously lighted.

The banks of fluorescent lights were operated by two time clocks. The day-night clock was responsible for activating the timer clock at a definite time period. The timer clock operated on a 1-hour cycle and was set to turn on the lights for 5 minutes during each 1-hour cycle. During the experiments these lights provided cyclic lighting by being adjusted to operate for approximately 5 minutes every hour from 8:00 P.M. until 12:00 midnight. The south end of the bench had no artificial illumination and was used as a comparison to determine the effect of the cyclic lighting. Reflection from the lights at the north end of the bench was blocked by a barrier of black plastic cloth suspended from the ceiling and extending out the full width of the bench. Readings taken at night with a Weston Illumination Meter indicated a light intensity at the cutting level of 63 foot candles under the fluorescent lights. The light meter did not record any light intensity in the non-lighted portion of the bench. The photographs shown in Figures 3 and 4 were taken in the greenhouse to illustrate the propagating bench and the position of the lights and black plastic barrier.

The entire propagating bench was equipped with time actuated overhead misting nozzles. The misting nozzles were placed 18 inches above the sand level in the bench. The misting control system was adjusted to wet the cuttings at two minute intervals for a period of 11 seconds. A time clock was set to operate the misting system from 6:00 A.M. until 12:00 midnight.

Electric heating cables were placed approximately a foot apart in the propagating bench. The heating cables were placed on a 2-inch layer of sand and covered with another inch of sand. The flats containing the cuttings were placed on the top sand layer. The optimum temperature for bottom heat is considered to be between 68° and 70°F. (16). The thermostatic control on the heating cables was adjusted to maintain the temperature in the flats as near 70°F. as possible. Metal flats which had been steam sterilized and filled with perlite, Horticultural grade No. 3, a sterile rooting media, were used to root the cuttings and were placed on the bench under the mist. A flat filled with perlite but not

Fig. 3. The propagating bench used in experiments 1 and 2 as viewed from the north end of the greenhouse.

Fig. 4. The propagating bench used in experiments 1 and 2 as viewed from the south end of the greenhouse.

containing any cuttings was placed on either end of the rooting bench to hold the thermocouples to record the temperature of the rooting media.

The greenhouse was heated by hot water forced through coils under the benches and was controlled by a thermostat. Two evaporative coolers with air outlets under the benches were used to cool the greenhouse. These coolers were not on a thermostat control which made it necessary to operate them manually.

An attempt was made to maintain the air temperature in the greenhouse between 60°F. and 80°F. There was a wide variation in the temperature readings in different locations within the greenhouse so a recording multipoint thermograph was used. The temperature at each station was recorded every five minutes. Three 24-hour readings were made to record the temperatures in the greenhouse and in the rooting media.

The entire propagating bench and the flats used for the second experiment were steam sterilized for 4 hours at 180°F. after the cuttings from the first experiment were removed.

Growth regulator solutions for treating the cuttings were prepared immediately before treating the cuttings. All the solutions were prepared from the crystaline form of the two growth regulators and dissolved in 50 per cent ethanol. Growth regulator solutions and concentrations used in the experiments were:

Indolebutyric acid (IBA) 4,000 ppm. (parts per million)

IBA 8,000 ppm.

Napthaleneacetic acid (NAA) 4,000 ppm.

NAA 8,000 ppm.

IBA-NAA 4,000 ppm. (2,000 ppm. IBA plus 2,000 ppm. NAA)

IBA-NAA 8,000 ppm. (4,000 ppm. IBA plus 4,000 ppm. NAA)

Fifty per cent ethanol was used as a dip for the cuttings in the control group.

Experiment 1: The cutting material was taken on December 21, 1962 from the male *Rhus lancea* tree located east of Maricopa Hall. The cuttings were all prepared and then divided into groups of 5, according to wood type. This was done so results would not be biased by all the cuttings in one group having come from one branch. Leaves were removed from the portion of the cutting to be inserted in the rooting media and the basal cut was made below a node. All flowers and flower buds were removed. The basal ends of four groups of 5 cuttings of firmwood and hardwood (greenwood was not available from *Rhus lancea* at that time of year) were dipped, 1 inch deep, for approximately 5 seconds in each growth regulator solution. Eight groups of 5 of both firmwood and hardwood cuttings were dipped in 50 per cent ethanol as a control.[1] This method corresponds to the concentrated dip method recommended by Audus (2). The cuttings were air dried after dipping in the growth regulator solution and placed in the flats. The groups of cuttings were randomized within the replications. Two replications were placed on the north end of the rooting bench under the lights and two replications were placed on the south end of the bench with no artificial illumination. The only shading given the cuttings during the day was from the very light whitewash on the greenhouse glass. Fallen leaves from the cuttings were removed from the flats to prevent contamination of the rooting media.

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[1]Twice the number of groups were used for the control because they correspond to the two different concentrations of the growth regulator solutions. This was necessary for the statistical analysis.

The cuttings were removed from the flats on March 6, 1963, 10 weeks after being placed in the flats. The number of cuttings rooted, the average number of roots per cutting (figured on the basis of rooted cuttings only), and the average length of the roots were recorded along with special observations.

Experiment 2: On April 10, 1963, cuttings were made from the male *Rhus lancea* tree located east of Maricopa Hall. Greenwood as well as firmwood and hardwood were used in this experiment. The cuttings were divided into groups of 5 according to the type of wood. All the basal cuts were made below a node and the leaves were removed from the portion of the cutting to be inserted in the rooting media. The basal ends of the cuttings in four groups each of greenwood, firmwood, and hardwood cuttings, were dipped in the growth regulator solutions for approximately 5 seconds. Eight groups of five from each type of wood were dipped in 50 per cent ethanol for the control. The cuttings were air dried prior to placing them in the flats. The groups of cuttings were randomized within the replications. Two replications were placed on the north end of the rooting bench under the lights and two replications were placed on the south end of the bench with no artificial illumination. The cuttings were shaded during the day by the light whitewash on the greenhouse glass. Fallen leaves were removed from the flats to prevent contamination. On May 4, 1963, the cuttings were removed from the flats and the data recorded as in experiment 1.

After the cuttings from the second experiment were removed a factorial analysis of variance based on the number of cuttings rooted, which was applicable to the design of the experiment, was run. For this analysis of variance see the Appendix.

EXPERIMENTAL RESULTS AND DISCUSSION

The results of the cyclic lighting, age of wood, growth regulators, and the concentration of the growth regulators in experiments 1 and 2 are shown in Tables 1 and 2 respectively.

In experiment 1 there was no significant difference in the number of cuttings rooted as affected by the absence or presence of cyclic lighting, age of wood or growth regulators. The concentration of the growth regulator solutions was significant at the 1 per cent level. Four thousand parts per million of growth regulator was shown to be superior to 8,000 ppm. as a dip for treating cuttings of *Rhus lancea*.

The only significant factor affecting rooting of cuttings in experiment 2 was the growth regulator and this was only at the 10 per cent level. IBA was superior in promoting rooting as compared to NAA and to IBA and NAA in combination.

The following observed events which took place during the time the cuttings were in the greenhouse may help to explain the lack of agreement in results of the two experiments. Probably the most important was the data from the recording multipoint thermograph. The thermograph had 20 thermocouples which recorded the temperature at each thermocouple every five minutes. The thermograph recordings did reveal a wide variance in temperature within the greenhouse during the day. The most striking difference recorded was that between thermocouples which were located next to the cuttings (under the mist) and those which were at the same

Table 1.--Percentage of cuttings of *Rhus lancea* rooting as affected by cyclic lighting, age of wood, growth regulator treatments, and the concentration of the growth regulator solutions in experiment 1.

	Percentage rooting
Under cyclic lighting	12.5
Control - No cyclic lighting	23.8
Firmwood cuttings	21.9
Hardwood cuttings	14.4
Naphthaleneacetic acid treatment	5.0
Indolebutyric acid treatment	12.5
Naphthaleneacetic plus Indolebutyric acid	10.6
Control - 50 per cent ethanol only	8.1
Growth regulators at 4,000 ppm.	31.7**
Growth regulators at 8,000 ppm.	5.8
Total cuttings rooted	18.1

**Significantly different at the 1 per cent level.

Table 2.--Percentage of cuttings of *Rhus lancea* rooting as affected by cyclic lighting, age of wood, growth regulator treatments, and the concentration of the growth regulator solutions in experiment 2.

	Percentage rooting
Under cyclic lighting	30.83
Control - No cyclic lighting	11.66
Greenwood cuttings	11.25
Firmwood cuttings	21.88
Hardwood cuttings	30.62
Naphthaleneacetic acid treatment	12.50
Indolebutyric acid treatment	35.83*
Naphthaleneacetic plus Indolebutyric acid	25.00
Control - 50 per cent ethanol only	11.66
Growth regulators at 4,000 ppm.	25.55
Growth regulators at 8,000 ppm.	23.33
Total cuttings rooted	21.25

*Significantly different at the 10 per cent level.

height but not under the mist. The highest temperature recorded in the greenhouse was 113°F. This recording was on April 13, 1963. This thermocouple was not located under the mist. During the same 5 minute period the recorded temperature next to the cuttings was 70°F. This serves to illustrate the extremes existing within the greenhouse. During most of the daytime hours the temperature next to the cuttings ranged from 60° to 70°F. and never over 70°F. while the misting system was in operation. The air temperature outside the mist area ranged from 70° to 90°F. most of the time. After dark the temperatures were more equal and after the mist shut-off for the night the temperatures did not vary more than 5°F. from one location to another.

Thermocouples inserted in the rooting media recorded a constant 73°F. on the north end of the bench, under the lights, and a constant 71°F. on the south end of the bench, not under the lights. This variance was due to not being able to adjust the thermostats on the heating cables as exactly as might be desired. This slight difference in temperature probably had very slight if any influence on the lack of agreement between experiments 1 and 2.

The cuttings in experiment 1 dropped leaves throughout the time they were under the mist. The cuttings in experiment 2 did not drop any leaves until they had been under the mist a week. The cuttings in experiment 2 were placed in flats under the mist on April 10, 1963. On April 15, 1963 the water was turned off during a construction period in that portion of the campus which includes the greenhouse being used for experiment 2. Due to this shut-off of water there was no mist being sprayed over the cuttings. It is not known just how long the water was off as the Horticulture Department was not informed of the turn-off. It was discovered that there was no mist being sprayed when the author entered the greenhouse about 2:30 P.M. From the appearance of the cuttings and the bench it appeared that the water was off about 2 hours. The temperature in the greenhouse at the time was 104°F. The coolers had not been turned on yet. On April 18 the leaves on the cuttings showed browning and bleaching so a plastic shading cloth was suspended across wires above the cuttings. This shading cloth filters out approximately 50 per cent of the sunlight. By April 25 about 80 per cent of the leaves on the cuttings had fallen and 90 per cent of the greenwood cuttings were dead.

It seems reasonable to assume that during the time the mist was off on April 15 the air temperature rose sharply from around 70°F. to about 100°F. in the vicinity of the cuttings, although thermograph readings were not being made on this day. This would probably be sufficient to cause sunburning and subsequent dropping of the leaves. It also seems reasonable to assume that this would cause a high mortality rate among the greenwood cuttings which were quite succulent.

It was interesting to note that at the time when the cuttings from experiments 1 and 2 were removed from the flats all cuttings which had either the original leaves or leaves from buds which had broken while in the flats, also had roots. In only a few instances did any cuttings have roots but no leaves.

The cuttings in experiment 1 were left in the rooting media for 10 weeks before being removed. The roots on many of the rooted cuttings were found to be rotting. A sample of these cuttings was taken to the

Plant Pathology Department and cultures from them did not show any pathogens present. In view of the rotting of roots in experiment 1 it was decided to leave the cuttings in experiment 2 in the rooting media a shorter length of time. The cuttings from the second experiment were left in the rooting media 8 weeks. When removed they also showed some rotting of roots but not as extensive as in the first experiment. These were again referred to the Plant Pathology Department and again no pathogens were found. In view of this it might be advisable on any future work with Rhus lancea to pot the cuttings as soon as they show signs of rooting. It may also have been the case that the cuttings were not able to support the roots once they were formed. Because all or most of the roots had rotted on many cuttings it was not possible to make an analysis of the number of roots per cutting or the length of the roots.

Figures 5, 6 and 7 show the type of roots present on the cuttings. The majority of the roots originated from the area around a node. It was of interest that no callus tissue was visible on any of the cuttings.

Fig. 5. Greenwood cuttings showing the size of the cuttings, the type of roots developed and their distribution on the cuttings.

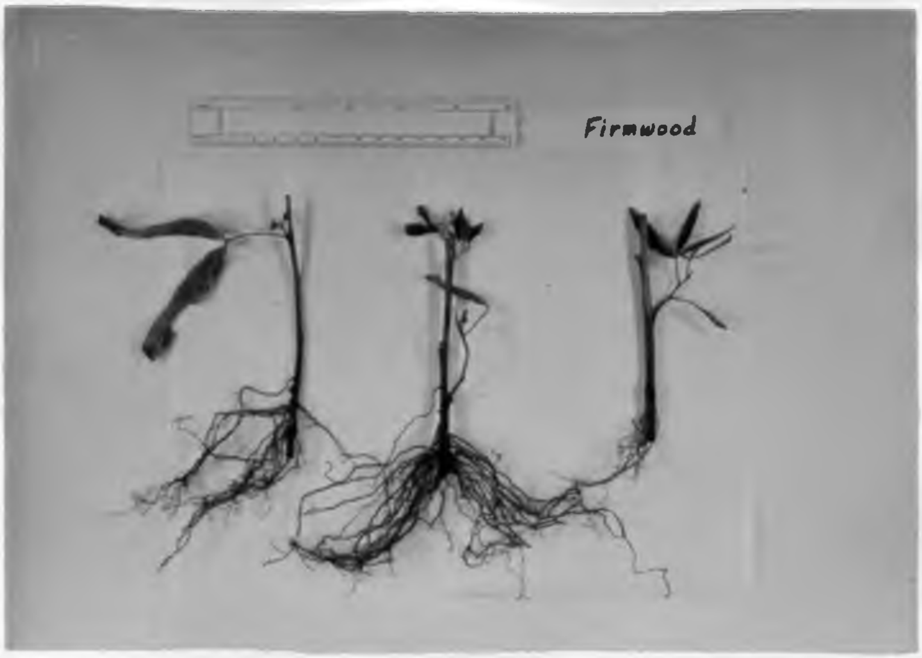

Fig. 6. Rooted firmwood cuttings.

Fig. 7. Rooted hardwood cuttings. The darkened lower halves of the cuttings were in the rooting media.

SUMMARY

Cuttings of *Rhus lancea* were made from a male tree and placed in flats of perlite December 20, 1962 and again on April 10, 1963. The effect on rooting of cyclic lighting, maturity of cutting material, growth regulators, and the concentration of the growth regulator solutions were studied.

An analysis of variance showed that only the concentration of the growth regulator solution in the first experiment was significant (at the 1 per cent level) in causing more cuttings to root. Four thousand ppm. of growth regulator was found to be superior to 8,000 ppm. The concentration of the growth regulator solution was not found to be significant in the second experiment. In both experiments cyclic lighting, maturity of cutting material, and the type of growth regulator used, had no significant effect on the number of cuttings rooted. Rotting of roots on some cuttings from both experiments indicated that cuttings of *Rhus lancea* should probably be removed from the rooting media as soon as roots are visible. Due to the mist having been turned off in the greenhouse during the second experiment it is doubtful that the results of the second experiment are of any value.

From the standpoint of the nurseryman, the rooting percentages found by these experiments are of little importance because of the economics involved. It has been shown however, that it is possible to root cuttings of _Rhus lancea_. In view of the latter fact and because it would be very desirable to propagate _Rhus lancea_ from cuttings so as to obtain all male trees, it would appear that further research into this problem might be profitable and that given the proper combination of circumstances, whatever they may be, higher percentages of rooting might be obtained.

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APPENDIX

Experiment 1

Analysis of variance of cuttings rooted.

Source	D. F.	S. Sq.	M. Sq.	F.
Total	31	86.88		
Light	1	10.12	10.12	.56
Cutting	1	4.50	4.50	3.98
Treatment	3	10.13	3.38	3.01
Replications	1	8.00	8.00	
Light x Replications	1	18.00	18.00	11.39**
Cuttings x Replications	1	1.13	1.13	.71
Treatments x Replications	3	3.35	1.12	.70
Error	20	31.65	1.58	

**Significant at the 1 per cent level

Experiment 1

Analysis of variance of cuttings rooted incorporating the interaction into the error term.

Source	D. F.	S. Sq.	M. Sq.	F.
Total	11	150.25		
Treatment	2	19.50	8.75	1.93
Concentration	1	80.08	80.08	17.68**
Replications	1	18.75	18.75	
Error	7	31.92	4.53	

**Significant at the 1 per cent level

Experiment 2

Analysis of variance of cuttings rooted incorporating the interaction into the error term.

Source	D. F.	S. Sq.	M. Sq.	F.
Total	11	154.67		
Treatment	2	98.17	49.09	6.38*
Concentration	1	1.34	1.34	.17
Replication	1	1.34	1.34	.17
Error	7	53.82	7.69	

*Significant at the 10 per cent level