BIBLIOGRAPHY

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Adviser: Dr. Araceli G. Ladilad, PhD

ABSTRACT

This study was conducted to determine the effects of pH of holding solution on the vaselife and cutflower quality of Peruvian Lily; and to determine the best pH of holding solution that will prolong the vaselife and preserve the quality of cutflowers.

Alstromeria cutflowers harvested at 50% anthesis were held in different pH of 3.0, 3.5, 4.0, 5.0 and 6.5 of the holding solution contain tapwater + 20% sucrose + 1 ml chlorox + citric acid.

Results showed using holding solutions with a pH of 4.0 containing 20% sucrose + 1 ml chlorox + citric acid promoted the longest duration of flower opening resulting to longer vaselife of cutflowers.

Likewise, holding solutions with a pH of 3.0 and 4.0 promoted better petal quality rating of Alstromeria cutflowers while holding solutions with pH of 4.0 and 5.0 also prolonged stem freshness thus, with a higher stem quality rating.

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INTRODUCTION

Peruvian lily (*Alstromeria sp.*) or lily of the Incas belongs to the family of Liliaceae, became an increasingly important part of the commercial cutflower trade. The flowers came in the variety of types and colors. All have a long postharvest life. Typically terminated by petal wilting and or drop and yellowing of leaves. The specie was subsequently named after The Swedish Consul in Spain, Clas Alstroemer.

Alstromeria, commonly called the Peruvian Lily or Lily of the Incas is a South American *genus* of about 50 *species* of flowering plants, mainly from cool, mountainous regions in the Andes. Alstromeria flowers are similar to lilies although smaller. The plants also tend to be quite small compared to lilies. These plants grow annually from tuber and can make large groups after a few years (Glick, 2001).

The plants are tuberous or rhizomatous perennials. The young plant start growing from main rhizome, sending up, per year, between 60-80 flowering stems. They grow to a height of 50-130 cm. Each erect stem grows foliage of a few lanceolate leaves and ends in an umbel of 3-10 flowers. These have six petals with spots, striped markings and contrasting patches (Glick, 2001).

Alstromeria, a new garden plant that is being grown for its beautiful, large infloresences of purple, lavender, red, pink, yellow, orange, white and bicolors. The flowers are delicate and trumpet like. Stems are 2-3 feet long. Since it has several flowers on one stem, it is a good flower to "fill in" the empty spots in an arrangement. In large bunch, *Alstromeria* looks lovely all by itself. Flowers of *Alstromeria* are highly sensitive to ethylene. Although untreated *Alstromeria* flowers have long vaselife; petal

drop (particularly a problem if there is ethylene in the environment). In some cutflowers, leaf yellowing occurs before flower senescence. It can be delayed by a pulse treatment with a preservative containing growth regulators (gibberellins or cytokinins).

Alstromeria grow best in full sun, but can also grow when given partial shade. Height of the plants will vary from 1-3 ft tall depending on the cultivars, the amount of light the plant receives, and plant cultures. Flowering stems are shorter on plants that are grown in full sun. Plant will also remain shorter during the growing season if flowering stems are removed after they bloom. *Alstromeria* plants that are grown in the garden respond positively to the application of mulch, watering procedures and fertilizers applied. The plant should be kept moist and cool, but should not be allowed in poorly drained soils. In cold regions, the rhizomes of Alstromeria can be stored and kept cool (1-3 ^{o}C) and not allowed to dry out.

For long-distance markets, flowers are harvested when the buds are about to open and start to color. For local markets, harvest is delayed until the first three flowers have opened. Flowers are pulled off or cut depending on the variety where pulling may damage the underground parts of the plant, the stem should be cut. If flowers are cut, the remaining stem should be removed later. At least one flower per stem should be open at time of purchase.

Growing *Alstromeria* can be developed as a profitable business in Baguio-Benguet. Production of *Alstromeria* cutflower could also provide a good source of income. Growers of cutflowers are not yet knowledgeable on the issues concerning postharvest losses as a result, the country's efficiency on cutflower production declines. The cutflower industry must then be quick to adopt the continually changing market

demand if it is to remain viable. This includes the need to respond to increasingly sophisticated cutflowers in terms of quality and volume.

Finally, it is hoped that this study will help *Alstromeria* growers and retailers in prolonging the postharvest life of their cutflowers and make these flowers available in the market on a year round basis.

The objective of the study was to determine the effects of different pH of holding solution on the vaselife of Peruvian Lily (*Alstromeria sp.*).

The study was conducted at the Department of Horticulture Service Laboratory, College of Agriculture, Benguet State University, La Trinidad, Benguet from December 2005 to March 2006.

REVIEW OF LITERATURE

Use of Preservatives

The main reason for the failure of cutflowers to develop and survive to an extent similar to that intact flowers are due to the lack of sufficient carbohydrate reserves needed for the growth and difficulties in the absorption of water apparently due to the formation of stem blockage in the stem of cutflowers attributed to physical and chemical causes (Rogers, 1973).

According to Rimando (1982) as cited by Nagpala (2003), preservative solutions are used to prolong vaselife, stimulate flower opening and to condition cutflowers and cutfoliage before shipment. The basic components of most preservatives are: a source of sucrose to enhance the water retaining capacity of the tissues and the a source of substrate; a germicide to help maintain the efficient uptake of water conducting function of the stem; an acidifying agent and buffer to inhibit the activity of certain enzymes and heavy metals to help stabilize color and prevent microbial build-up.

Fifty percent of 7-up (carbonated soda) solution significantly lengthen the vaselife of some cutflower compared to other holding solutions (Ladilad, 1980). Sugar supports the processes fundamental for prolonging vaselife such as maintaining mitochondrial structure and functions, improving water balance by regulating transportation and increasing water uptake. All sugar present in floral preservatives make excellent media for the growth of microorganism that plug water vessels in a stem. Therefore, sugar must be combined with germicide in the preservative mixture.

Longevity of Flowers

Temperature is the major factor affecting the storage and vaselife of flowers. This is through its influence on the respiration rate of the flowers and their response to ethylene, moisture loss and physical change. Cooling is also necessary to reduce other metabolic activities and to show the rate of opening of flower. The temperature of flower at harvest is normally close to that of the ambient air. At this temperature respiration activity is very high and storage/vaselife will be short. Ethylene reduces the longevity of some flowers and foliage by causing rapid wilting of petals, shedding or shattering of petals or other change to petal tissues such as loss or change of color. Therefore, flowers which are sensitive to ethylene should not be held in the same cool store as ethylene producing fruits, vegetable or foliage or be exposed to exhaust fumes.

According to Coorts (1965), the respiratory rate for intact rose was quite high and reduced at minimum at the time when the sepals had folded out from the developing bud. At commercial harvest, when the first petals were breaking away from the flower body, respiration declined.

Further, he stated that to maintain cutflower quality, cutflower should be harvested at the right stage of maturity; however, maturity stages vary from flower to flower under different cultural and marketing situations. In most cases, flowers are cut at the harvest stage in order to assure full opening in the vase.

Holding Solutions

Sucrose as a holding solution is beneficial because it is the source of energy due to the closure of stomata and reduction of water loss (Wheally, 1992). Marovsky (1969) found that sucrose solution increased the fresh weight and longevity of cutflowers.

According to Rimando (1982), the optimum leaves of sucrose must be provided to successfully open cutflowers to quality blooms. Furthermore, the preservatives in addition to extending the vaselife of cutflowers had been used as opening solutions for cutflowers harvested at immature stage of flower development.

Floral Preservatives

Sucrose had been shown to increase the fresh weight and longevity of cutflowers. Sucrose also reduces moisture stress in cutflowers by decreasing the size of leaf stomata (Marovsky, 1969). Flowers held in sucrose were comparable to field opened flowers. Sucrose in the holding solution is beneficial because it is the source of energy of cutflowers.

There is probably no preservative that is equally effective for all flower types; the optimal concentration of the different components of preservatives would vary from flower to flower (Rimando and Maralit, 1980).

Organic acids are used to lower the pH of the solution. A low pH was shown to favor the activity of the presumed enzyme since acidification of the vase water tends to minimize physiological stem blockage (Coorts, 1965). A pH of 3.5 to 4.0 extends shelf-life because it inhibits indigenous enzymes essential for stem plugging (Rimando, 1982).

Senescence

A freshly cut flower is still living and is an actively metabolizing entity whose life span is subsequently terminated by senescence, as distinguished from aging which involves gradual changes that are deteriorative but not lethal in themselves (Leopold, 1975).

Senescence is a concept of physiological and biochemical process. The initial event of senescence remains obscure, during the development of some cutflowers like carnation and rose, a climacteric rise in ethylene production signifies the promotion of senescence. Therefore, a change in permeability of the tissues can be detected (Mayak, 1987).

Water pH

Acidity alteration is the most important of the three considerations of components of floral preservatives since alkaline or high pH water/solution is damaging to cutflowers. Reduced water potential of the holding solution usually influences and decreases pH of water and sugar uptake. A low pH inhibits indigenous enzymes essential for stem plugging and tends to minimize physiological stem blockage (Reid, 2000).

Various chemicals are used to increase the acidity of a solution. The most available chemical is vinegar. However, vinegar whitened the stem submerged in the solution.

MATERIALS AND METHODS

Materials

The materials used were *Alstromeria* cutflowers, catsup bottles and holding solutions, stirring rod, beaker and weighing balance used in the preparation of the solution. A pH meter utilized for determining the pH level of the preservative solutions.

The preservative or holding solutions used were the following:

1. Ascorbic acid (to replace citric acid) at different rates to vary the pH solution.
2. Sucrose - 20% by weight
3. Chlorox - 1 ml/l solution

Methods

Newly harvested *Alstromeria* flowers at 50% anthesis were obtained from a flower shop in Baguio City. The stem ends were cut back about 1 cm and soaked for one (1) night in tap water before being held in the different holding solutions.

The experiment was laid out following the completely randomized design (CRD) with three replications and was conducted at ambient room temperature averaging 15 ^{0}C-16^{0}C. Two flowers represented one treatment replication. The following were the treatments:

Treatment	pH of the Holding Solution
T_1	3.0
T_2	3.5
T_3	4.0
T_4	5.0
T_5	6.0
T_6	7.0 (control) - tap water only

The data gathered were:

1. Vaselife (Days). The number of days covering the period from holding of the cutflower in the solution up to the termination of the aesthetic value of the flowers.

2. Volume of solution taken-up (ml). The final volume of solution per treatment at the termination of the postharvest life of the sample flowers was deducted from the initial volume of 200 ml per catsup bottle.

3. Number of days from immersion to full flower opening. This was done by recording the number of days from immersion to full flower opening.

4. Petal quality rating. The quality of petals of each flower was noted daily using the following index:

Rating Index	Description
1	51 - 60% open
2	61 - 80% open
3	81 - 100% open

5. Stem quality. The stem quality of each flower was rated using the following rating:

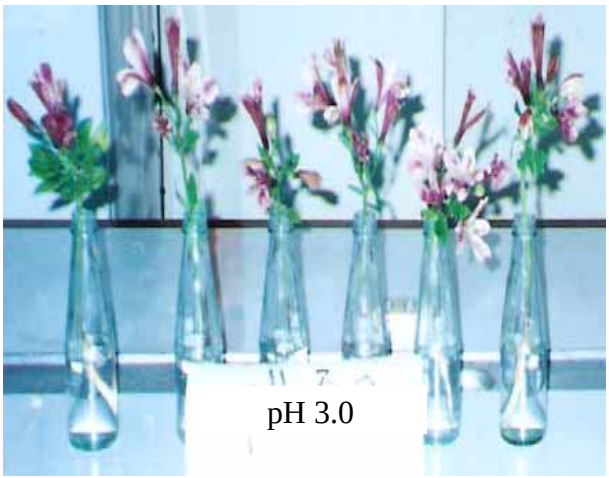
Rating Index	Description
1	dark green, no injury
2	dark green and rotting at the base (2.0 cm)
3	dark green and rotting at the base (2.5 cm)
4	green and rotting at the base (3.0 cm)
5	green and rotting at the base (3.5 cm)
6	yellow green and rotting at the base (4.0 cm)
7	yellow green and rotting at the base (4.5 cm)

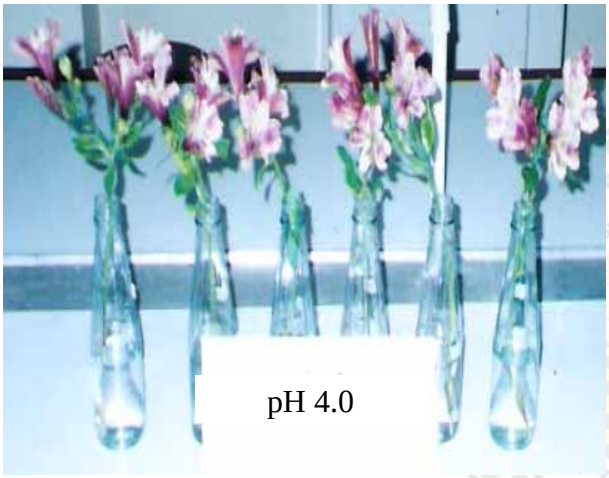
6. Leaf quality rating. This was obtained by using the following rating index:

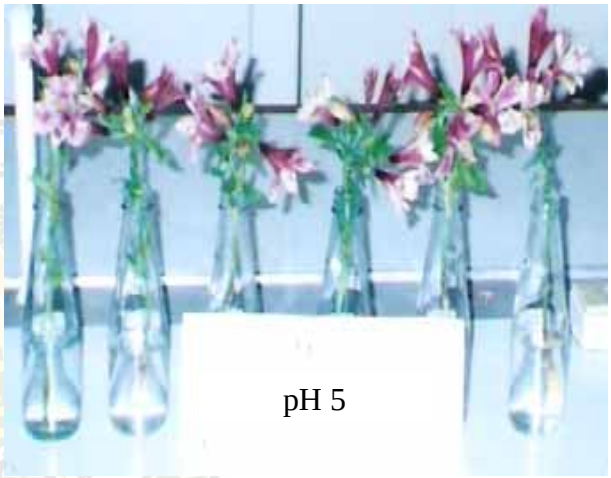
Rating Index	Description
1	1 - 20% yellowing of the leaves
2	21 - 40% yellowing of the leaves
3	51 - 60% yellowing of the leaves
4	61 - 80% yellowing of the leaves
5	81 - 100% yellowing of the leaves

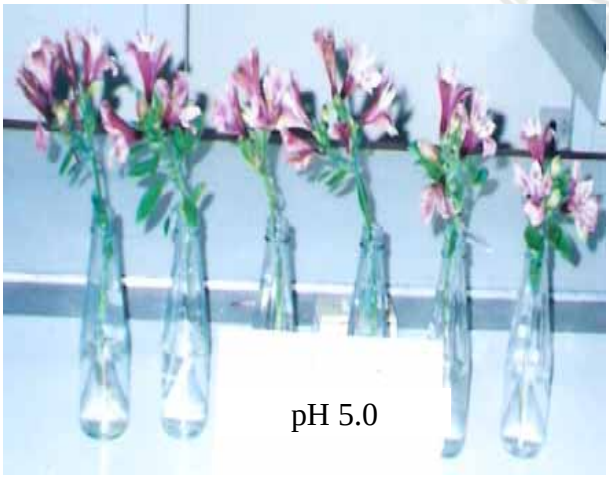
7. Documentation of the study in pictures.

Plate 1. Overview of the experimental cutflowers









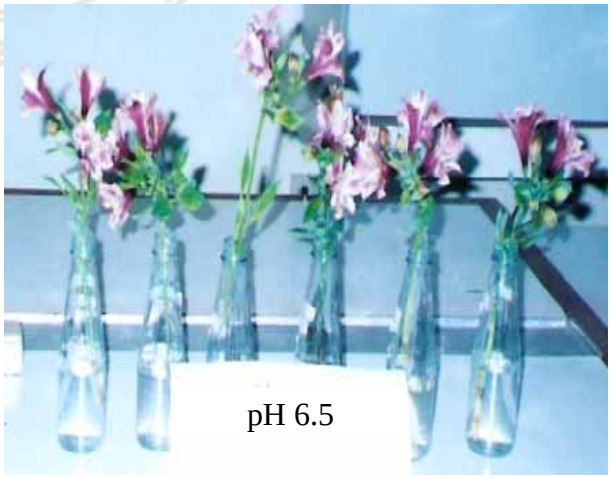


Plate 2. Overview of the cutflowers at various pH range

RESULTS AND DISCUSSIONS

Vaselife

Table 1 shows that Alstromeria cutflowers held in holding solutions and tapwater only with a pH of 3.5, 5.0, 6.0 and 6.5 had the longest vaselife of 18 days followed by those held in 20% sucrose + 1 ml chlorox + citric acid with a pH of 4.0 had a vaselife of 17.66 days. Flowers held in solutions with 20% sucrose + 1 ml chlorox + citric acid with a pH of 3.0 had the shortest vaselife of 16.66 days.

However, statistical analysis did not show any significant differences among the different pH of the holding solutions as far as vaselife is concerned. Further, the onset of senescence may be related to some antecedent changes that occur before harvest. The most decisive factor, however, which may trigger senescence of cutflower at any stage of its development. Senescence concerns physiology and biochemical processes (Mayak, 1987). Havey and Mayak (1979) further stated that the most obvous symptoms of the final stages of senescence is the loss of fresh weight, drying and shrivelling. Further, Rimando (1980) stated that the loss of turgidity, exposure to ethylene and shortage of respirable substances are the most decisive factor which may trigger the onset of senescence of cutflower at any stage of their development whether they are still attached or already detached from the plant. Waters (1966) concluded that proper storage, methods and postharvest procedures can extend vaselife but if not used correctly may reduce vaselife.

Table 1. Vaselife (days)

TREATMENT	MEAN
pH 3.0	16.67a
pH 3.5	18.00a
pH 4.0	17.67a
pH 5.0	18.00a
pH 6.0	18.00a
pH 6.5	18.17a

Means with same letter are not significantly different at 5% level by DMRT

Volume of Solution Taken-up

Statistical analysis showed that there were no significant differences in the volume of solution taken-up by the alstromeria cutflowers as affected by the different pH levels in the holding solutions. Cutflowers held in a solution with pH 4.0 had higher rate of absorption, taking up 48.33 ml of the holding solution at the termination followed by those held in solutions with pH of 6.5, 3.5, 5.0 and 6.0 whereas flowers held in solution with a pH of 3 absorbed the least.

Number of Days from Flower Immersion to Full Flower Opening

The number of days to full flower opening ranged from 6 to 9 days. Statistical analysis showed significant differences obtained on the number of days from immersion to full flower opening as affected by the different pH levels of the holding solution (Table 3). Cutflowers held in 20% sucrose + 1 ml chlorox + citric acid with a pH of 4.0 promoted the longest duration of flower opening with a mean of 9.0 days followed by those held in

Table 2. Volume of solution taken-up (ml)

TREATMENT	MEAN
pH 3.0	35.83a
pH 3.5	43.50a
pH 4.0	48.33a
pH 5.0	39.67a
pH 6.0	38.33a
pH 6.5	45.33a

Means with same letter are not significantly different at 5% level by DMRT

solutions with pH 5, 6.5 and 6.0; whereas alstromeria cutflowers held at pH 3.0 and 3.5 had the shortest duration to flower opening with full opened flowers after 6.5 and 6.6 days.

Rimando and Maralit (1980) found that in Shasta daisy the presence of 10% sucrose resulted in the successful further opening of cutflower buds to quality blooms which was comparable and even bigger than field opened blooms. However, 8% sucrose appeared to be the optimum sugar level as regards to vaselife irrespective of flower bud stage at harvest.

Petal Quality Rating

The petal quality rating for all the cutflowers in the experiment was done every two days.

Statistical anlysis showed that there was no significant differences from day 2 to day 4 on the petal quality rating of alstromeria cutflowers held in holding solutions with different pH.

Table 3. Number of days from immersion to full flower opening

TREATMENT	MEAN
pH 3.0	6.50b
pH 3.5	6.67b
pH 4.0	8.50a
pH 5.0	7.17b
pH 6.0	7.00b
pH 6.5	7.17b

Means with same letter are not significantly different at 5% level by DMRT

On the 6th day, Alstromeria cutflowers held in the solutions with a pH 3.0, 3.5 and 4.0 had the highest petal quality rating of 1.5, while those held in the solutions with a pH of 5.0 and 6.5 had the lowest petal quality rating of 2.33.

On the 8th day, there were no significant differences noted on the petal quality rating. On the 10th, cutflowers held in solutions with a pH of 3.0 and 4.0 had the highest petal quality rating of 2.17 while the lowest petal quality rating was observed in solutions with pH 5.0, 6.0 and 6.5, both had a mean of 3.0.

On the 12th day, highest petal quality rating was observed in cutflowersheld in solutions with a pH of 4.0 with a mean of 2.50 while the lowest petal quality rating was noted on the solution with a pH of 5, 6 and 6.5 with a mean of 3.0.

From day 14 to 18, cutflowers held in solutions with the different pH had all the same means of 3.0 which means that all the flower petals are fully opened.

Table 4. Petal quality rating

TREATMENT	DAY 2	DAY 4	DAY 6	DAY 8	DAY 10
pH 3.0	1.0a	1.0a	1.50a	1.83a	2.17a
pH 3.5	1.0a	1.0a	1.50a	1.83a	2.33a
pH 4.0	1.0a	1.0a	1.50a	1.83a	2.17a
pH 5.0	1.0a	1.0a	2.33a	2.83a	3.00a
pH 6.0	1.0a	1.0a	2.17a	2.67a	3.00a
pH 6.5	1.0a	1.0a	2.33a	2.83a	3.00a

Means with same letter are not significantly different at 5% level by DMRT

Table 4b. Petal quality rating

TREATMENT	DAY 12	DAY 14	DAY 16	DAY 18
pH 3.0	2.83a	3.00a	3.00a	3.00a
pH 3.5	2.83a	3.00a	3.00a	3.00a
pH 4.0	2.50a	3.00a	3.00a	3.00a
pH 5.0	3.00a	3.00a	3.00a	3.00a
pH 6.0	3.00a	3.00a	3.00a	3.00a
pH 6.5	3.00a	3.00a	3.00a	3.00a

Means with same letter are not significantly different at 5% level by DMRT

Leaf Quality Rating

Statistical analysis showed that there were no significant differences observed on the 2nd day of observations on the leaf quality rating of Alstromeria cutflowers held in solution with different pH.

On day 4, no significant differences were likewise observed; however, Alstromeria cutflowers held in a solution with pH 3.0 had the highest leaf quality rating with a mean of 1.17 while the lowest quality rating was observed on the cutflowers held in a solution with pH 3.0, 4.0 and 5.0 with a mean of 1.67.

On day 6, Alstromeria cutflowers held in solution with a pH of 6.0 had the highest leaf quality rating of 1.5 while the lowest quality was observed on the cutflowers held in solution with a pH of 3.5 and 4.0 with a mean of 2.17.

On day 8, Alstromeria cutflowers held in a solution with a pH of 6.0 and 6.5 had the highest leaf quality rating of 2.17 while the lowest leaf quality rating was observed on the cutflowers held in solution with a pH of 3.5 with a mean of 2.83.

On the 10^{th} day, highest quality rating was observed on the cutflowers held in solutions with a pH of 3.5 and 4.0 both had a mean of 3.0 while the lowest leaf quality rating was observed on the cutflower held in a solution with a pH of 3.0 and 5.0 with a mean of 3.33.

On the 12^{th} day, cutflowers held in a solution with a pH of 3.5 and 6 had the highest leaf quality rating of 3.83 while the lowest leaf quality rating was observed on the cutflowers held in a solution with a pH of 5 with a mean of 4.33.

Stem Quality

Statistical analysis showed that there was no significant differences from day 2 to 8 on the stem quality of Alstromeria as affected by the different pH levels of the holding solution.

Table 5. Leaf quality rating

TREATMENT	DAY 2	DAY 4	DAY 6	DAY 8	DAY 10
pH 3.0	1.0	1.17a	2.00a	2.67a	3.33a
pH 3.5	1.0	1.50a	2.17a	2.83a	3.00a
pH 4.0	1.0	1.67a	2.17a	2.33a	3.00a
pH 5.0	1.0	1.67a	2.00a	2.33a	3.33a
pH 6.0	1.0	1.67a	1.50a	2.17a	3.17a
pH 6.5	1.0	1.67a	1.83a	2.17a	3.17a

Means with same letter are not significantly different at 5% level by DMRT

Table 5b. Leaf quality rating

TREATMENT	DAY 12	DAY 14	DAY 16	DAY 18
pH 3.0	4.17a	4.83a	4.83a	5.00a
pH 3.5	3.83a	4.67a	5.00a	5.00a
pH 4.0	4.17a	4.67a	5.00a	5.00a
pH 5.0	4.33a	4.67a	5.00a	5.00a
pH 6.0	3.83a	4.33a	4.83a	5.00a
pH 6.5	4.00a	4.17a	4.83a	5.00a

Means with same letter are not significantly different at 5% level by DMRT

On day 10, Alstromeria cutflowers held in the solution with a pH of 3.5, 4.5 and 6 had the highest mean of 1.83 while cutflowers held in the solution with a pH of 3.0 had the lowest quality rating of 2.17.

On the 12th day, highest stem quality rating was observed in the solution with a pH of 6.0 with a mean of 2.17 while cutflowers held in solution with a pH of 3 and 3.5 had the lowest stem quality rating with a mean of 3.17.

On day 14, highest stem quality rating was observed in the solution with a pH of 6.0 and 6.5 with a mean of 3.17 while the lowest stem quality rating was noted on the solution with a pH of 3.0 with a mean of 4.17 which means that the stems were still dark green.

On the 16th day, cutflowers held in the solution with a pH of 5.0 had the highest stem quality rating of 3.83 while those held in the solution with a pH of 3 had the lowest stem quality rating of 4.50.

On the last day of observation, cutflowers held in a solution with a pH of 4.0 and 5.0 had the highest stem quality rating of 4.33 while, those held at pH 6.5 had the lowest stem quality, the stems were green and rotting at the base.

Other Observation

Fungal mycellia were noted at the stem ends in alstromeria cutflowers held in solutions with pH 5.0, 6.0 and 6.5 on the last day of observations.

Table 6. Stem quality rating

TREATMENT	DAY 2	DAY 4	DAY 6	DAY 8	DAY 10
pH 3.0	1.0	1.0	1.0	1.0	2.17a
pH 3.5	1.0	1.0	1.0	1.0	1.83a
pH 4.0	1.0	1.0	1.0	1.0	1.83a
pH 5.0	1.0	1.0	1.0	1.0	1.83a
pH 6.0	1.0	1.0	1.0	1.0	1.83a
pH 6.5	1.0	1.0	1.0	1.0	2.00a

Means with same letter are not significantly different at 5% level by DMRT

Table 5b. Stem quality rating

TREATMENT	DAY 12	DAY 14	DAY 16	DAY 18
pH 3.0	3.17a	4.17a	4.50a	5.00a
pH 3.5	3.17a	3.83a	4.33a	5.00a
pH 4.0	2.50a	3.53a	4.83a	4.33a
pH 5.0	2.67a	3.50a	4.00a	4.33a
pH 6.0	2.17a	3.17a	3.83a	4.67a
pH 6.5	2.33a	3.17a	4.33a	5.17a

Means with same letter are not significantly different at 5% level by DMRT

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

Alstromeria cutflowers were harvested at 50% anthesis and were held in holding solutions containing 20% sucrose + 1 ml chlorox + citric acid.

Results showed that alstromeria cutflowers harvested at 50% anthesis held in tapwater only and in holding solutions with pH 6.5, 6.0, 5.0 and 3.5 had longer vaselife compared to cutflowers held in holding solutions with pH 3.0, 4.0 and 5.0 which had the shortest vaselife.

All the cutflowers held in solutions with different pH showed different extents of stem damage and had yellowing of the leaves at the termination of observations.

The lowest cutflower quality rating were recorded in cutflowers held in solutions containing 20% sucrose + 1 ml Chlorox + citric acid with a pH of 6.0. Cutflowers held in solutions containing 20% sucrose + 1 ml Chlorox + citric acid with a pH of 4 and 5 had higher stem quality rating on the last day of observations compared to other treatments.

Conclusion

Results showed that using holding solution with a pH of 4.0 containing 20% sucrose + 1 ml Chlorox + citric acid promoted the longest duration of flower opening resulting to longer vaselife of Alstomeria cutflowers.

Recommendation

Based on the findings, it is recommended that using a holding solution with a pH of 4.0 containing 20% sucrose + 1 ml Chlorox + citric acid can be used to promote longer duration of flower opening, thereby promoting longer cutflower vaselife.

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APPENDICES

APPENDIX TABLE 1. Vaselife

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	16	16	18	50.00	16.67
T_2	18	18	18	54.00	18.00
T_3	17	18	18	53.00	17.67
T_4	18	17	18	54.00	18.00
T_5	18	18	18	54.00	18.00
T_6	18	18	18	54.50	18.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	5	4.625	0.925	3.171ns	3.11	5.06
Error	12	3.500	0.292			
TOTAL	17					

Coefficient of variation = 3.04%

APPENDIX TABLE 2. Volume of solution taken-up

TREATMENT	REPLICATION I	REPLICATION II	REPLICATION III	TOTAL	MEAN
T_1	37.50	32.50	37.50	107.50	35.83
T_2	38.00	37.50	55.00	130.50	43.50
T_3	50.00	50.00	45.00	145.00	48.33
T_4	41.50	40.00	37.50	119.00	39.67
T_5	32.50	45.00	37.50	115.00	38.33
T_6	55.00	43.50	37.50	136.00	45.33
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	5	330.667	66.133	1.663ns	3.11	5.06
Error	12	477.333	39.778			
TOTAL	17					

Coefficient of variation = 15.08%

APPENDIX TABLE 3. Days from immersion to full flower opening

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	6.0	6.5	7.0	19.50	5.60
T_2	7.0	6.5	6.5	20.00	6.67
T_3	8.5	9.0	8.0	25.50	8.50
T_4	7.0	7.0	7.5	21.50	7.17
T_5	6.5	7.5	7.0	21.00	7.00
T_6	7.5	7.5	6.5	21.50	7.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	5	7.500	1.500	7.200**	3.11	5.06
Error	12	2.500	0.208			
TOTAL	17					

Coefficient of variation = 6.37%

APPENDIX TABLE 4. Petal quality rating (day 2)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 5. Petal quality rating (day 4)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 6. Petal quality rating (day 6)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.5	2.0	1.0	4.5	1.50
T_2	2.0	1.5	1.0	4.5	1.50
T_3	2.0	1.5	1.0	4.5	1.50
T_4	2.0	3.0	2.0	7.0	2.33
T_5	1.0	3.0	2.5	6.5	2.17
T_6	3.0	2.0	2.0	7.0	2.33
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	2.778	0.556	1.333ns	3.11	5.06
Error	12	5.000	0.417			
TOTAL	17	7.778				

Coefficient of variation = 34.17%

APPENDIX TABLE 7. Petal quality rating (day 8)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.5	2.0	2.0	5.5	1.83
T_2	2.0	2.0	1.5	5.5	1.83
T_3	2.0	2.0	1.5	5.5	1.83
T_4	4.0	2.5	2.0	8.5	2.83
T_5	3.5	2.5	2.0	8.0	2.67
T_6	4.0	2.5	2.0	8.5	2.83
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	4.069	0.814	1.628ns	3.11	5.06
Error	12	6.000	0.500			
TOTAL	17	10.069				

Coefficient of variation = 30.67%

APPENDIX TABLE 8. Petal quality rating (day 10)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.0	1.0	2.5	6.5	2.17
T_2	2.0	3.0	2.0	7.0	2.33
T_3	3.0	2.5	1.0	6.5	2.17
T_4	3.0	3.0	3.0	9.0	3.00
T_5	3.0	3.0	3.0	9.0	3.00
T_6	3.0	3.0	3.0	9.0	3.00
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	2.778	0.925	1.333ns	3.11	5.06
Error	12	5.000	0.292			
TOTAL	17	7.778				

Coefficient of variation = 3.04%

APPENDIX TABLE 9. Petal quality rating (day 10)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	4.625	0.925	3.171ns	3.11	5.06
Error	12	3.500	0.292			
TOTAL	17					

Coefficient of variation = 3.04%

APPENDIX TABLE 10. Petal quality rating (day 12)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	4.0	2.5	2.0	8.5	2.83
T_2	2.5	2.0	4.0	8.5	2.83
T_3	3.0	2.5	2.0	7.5	2.50
T_4	3.0	3.0	3.0	9.0	3.00
T_5	3.0	3.0	3.0	9.0	3.00
T_6	3.0	3.0	3.0	9.0	3.00
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.569	0.114	0.283ns	3.11	5.06
Error	12	4.833	0.403			
TOTAL	17	5.403				

Coefficient of variation = 22.18%

APPENDIX TABLE 11. Petal quality rating (day 14)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.0	3.0	3.0	9.0	3.0
T_2	3.0	3.0	3.0	9.0	3.0
T_3	3.0	3.0	3.0	9.0	3.0
T_4	3.0	3.0	3.0	9.0	3.0
T_5	3.0	3.0	3.0	9.0	3.0
T_6	3.0	3.0	3.0	9.0	3.0
TOTAL					

APPENDIX TABLE 12. Petal quality rating (day 16)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.0	3.0	3.0	9.0	3.0
T_2	3.0	3.0	3.0	9.0	3.0
T_3	3.0	3.0	3.0	9.0	3.0
T_4	3.0	3.0	3.0	9.0	3.0
T_5	3.0	3.0	3.0	9.0	3.0
T_6	3.0	3.0	3.0	9.0	3.0
TOTAL					

APPENDIX TABLE 13. Petal quality rating (day 18)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.0	3.0	3.0	9.0	3.0
T_2	3.0	3.0	3.0	9.0	3.0
T_3	3.0	3.0	3.0	9.0	3.0
T_4	3.0	3.0	3.0	9.0	3.0
T_5	3.0	3.0	3.0	9.0	3.0
T_6	3.0	3.0	3.0	9.0	3.0
TOTAL					

APPENDIX TABLE 14. Stem quality rating (day 2)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 15. Stem quality rating (day 4)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 16. Stem quality rating (day 4)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 17. Stem quality rating (day 6)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 18. Stem quality rating (day 8)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 19. Stem quality rating (day 10)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	2.5	2.0	2.0	6.5	2.17
T_2	2.0	2.0	1.5	5.5	1.83
T_3	2.0	2.0	1.5	5.5	1.83
T_4	2.0	1.5	2.0	5.5	1.83
T_5	2.0	2.0	1.5	5.5	1.83
T_6	2.0	2.0	2.0	6.0	2.00
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.292	0.058	0.840ns	3.11	5.06
Error	12	0.833	0.069			
TOTAL	17	1.125				

Coefficient of variation = 13.75%

APPENDIX TABLE 20. Stem quality rating (day 12)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.5	3.0	3.0	9.5	3.17
T_2	3.0	3.0	3.5	9.5	3.17
T_3	3.5	2.0	2.0	7.5	2.5
T_4	3.5	2.5	2.0	8.0	2.67
T_5	2.0	2.0	2.5	6.5	2.17
T_6	2.0	3.0	2.0	7.0	2.33
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	2.667	0.533	1.671ns	3.11	5.06
Error	12	3.833	0.319			
TOTAL	17	6.500				

Coefficient of variation = 21.19%

APPENDIX TABLE 21. Stem quality rating (day 14)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	4.0	3.5	12.50	4.17
T_2	4.5	3.5	3.5	11.50	3.83
T_3	4.5	3.0	3.0	10.55	3.53
T_4	4.0	3.0	3.0	10.55	3.50
T_5	3.0	3.5	3.0	9.50	3.17
T_6	3.5	3.0	3.0	9.50	3.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	2.403	0.481	1.331ns	3.11	5.06
Error	12	4.333	0.361			
TOTAL	17	6.736				

Coefficient of variation = 17.03%

APPENDIX TABLE 22. Stem quality rating (day 16)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	4.5	4.0	13.5	4.50
T_2	5.0	4.0	4.0	13.0	4.33
T_3	4.5	3.5	3.5	11.5	3.83
T_4	5.0	4.0	3.0	12.0	4.00
T_5	4.5	3.5	3.5	11.5	3.83
T_6	3.0	4.0	3.0	12.0	4.00
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	2.569	0.514	1.194ns	3.11	5.06
Error	12	5.167	0.431			
TOTAL	17	7.736				

Coefficient of variation = 16.52%

APPENDIX TABLE 23. Stem quality rating (day 18)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	5.0	5.0	15.0	5.00
T_2	5.0	5.0	5.0	15.0	5.00
T_3	5.0	4.0	4.0	13.0	4.33
T_4	4.0	4.0	5.0	13.0	4.33
T_5	5.0	5.0	4.0	14.0	4.67
T_6	5.5	5.0	5.0	15.5	5.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	1.958	0.392	2.169ns	3.11	5.06
Error	12	2.167	0.181			
TOTAL	17	4.125				

Coefficient of variation = 8.95%

APPENDIX TABLE 24. Leaf quality rating (day 2)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
T_1	1.0	1.0	1.0	3.0	1.0
T_2	1.0	1.0	1.0	3.0	1.0
T_3	1.0	1.0	1.0	3.0	1.0
T_4	1.0	1.0	1.0	3.0	1.0
T_5	1.0	1.0	1.0	3.0	1.0
T_6	1.0	1.0	1.0	3.0	1.0
TOTAL					

APPENDIX TABLE 25. Leaf quality rating (day 4)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	1.5	1.0	1.0	3.5	1.17
T_2	1.5	2.0	1.0	4.5	1.50
T_3	2.0	1.0	2.0	5.0	1.67
T_4	2.0	1.0	2.0	5.0	1.67
T_5	1.5	1.0	1.0	3.5	1.17
T_6	1.5	1.0	1.0	3.5	1.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.944	0.189	0.971ns	3.11	5.06
Error	12	2.333	0.194			
TOTAL	17	3.278				

Coefficient of variation = 31.75%

APPENDIX TABLE 26. Leaf quality rating (day 6)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	2.5	2.0	1.5	6.0	2.00
T_2	2.5	2.0	2.0	6.5	2.17
T_3	2.5	2.0	2.0	6.5	2.17
T_4	2.0	2.0	2.0	6.0	2.00
T_5	1.5	2.0	1.0	4.5	1.50
T_6	1.5	2.0	2.0	5.5	1.83
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.944	0.189	1.511ns	3.11	5.06
Error	12	1.500	0.125			
TOTAL	17	2.444				

Coefficient of variation = 18.18%

APPENDIX TABLE 27. Leaf quality rating (day 8)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	3.5	2.5	2.0	8.0	2.67
T_2	4.0	2.5	2.0	8.5	2.83
T_3	3.0	2.0	2.0	7.0	2.33
T_4	2.0	2.0	3.0	7.0	2.33
T_5	3.0	1.0	2.5	6.5	2.17
T_6	1.0	3.0	2.5	6.5	2.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	1.125	0.225	0.300ns	3.11	5.06
Error	12	9.000	0.750			
TOTAL	17	10.125				

Coefficient of variation = 35.84%

APPENDIX TABLE 28. Leaf quality rating (day 10)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	4.0	3.0	3.0	10.00	3.33
T_2	3.0	3.0	3.0	9.00	3.00
T_3	3.0	3.0	3.0	9.00	3.00
T_4	2.5	2.5	5.0	10.00	3.33
T_5	3.5	3.0	3.0	9.50	3.17
T_6	3.5	3.0	3.0	9.50	3.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Treatment	5	0.333	0.067	0.155ns	3.11	5.06
Error	12	5.167	0.431			
TOTAL	17	5.500				

Coefficient of variation = 20.72%

APPENDIX TABLE 29. Leaf quality rating (day 12)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	4.0	4.0	4.5	12.5	4.17
T_2	4.0	4.0	3.5	11.5	3.83
T_3	4.5	4.0	4.0	12.5	4.17
T_4	5.0	4.0	4.0	13.0	4.33
T_5	3.5	4.0	4.0	11.5	3.0
T_6	4.0	4.0	4.0	12.0	1.0
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.611	0.122	1.100ns	3.11	5.06
Error	12	1.333	0.111			
TOTAL	17	1.944				

Coefficient of variation = 8.22%

APPENDIX TABLE 30. Leaf quality rating (day 14)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	5.0	4.5	14.5	4.83
T_2	5.0	4.5	4.5	14.0	4.67
T_3	4.5	4.5	5.0	14.0	4.67
T_4	5.0	4.5	4.5	14.0	4.67
T_5	5.0	4.0	4.0	13.0	4.33
T_6	4.5	4.0	4.0	12.5	4.17
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.944	0.189	1.511ns	3.11	5.06
Error	12	1.500	0.125			
TOTAL	17	2.444				

Coefficient of variation = 7.76%

APPENDIX TABLE 31. Leaf quality rating (day 16)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	5.0	4.5	14.5	4.83
T_2	5.0	5.0	5.0	15.0	5.00
T_3	5.0	5.0	5.0	15.0	5.00
T_4	5.0	5.0	5.0	15.0	5.00
T_5	5.0	5.0	4.5	14.5	4.83
T_6	5.0	5.0	4.5	14.5	4.83
TOTAL					

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Treatment	5	0.125	0.025	0.600ns	3.11	5.06
Error	12	0.500	0.042			
TOTAL	17	0.625				

Coefficient of variation = 4.15%

APPENDIX TABLE 32. Leaf quality rating (day 18)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
T_1	5.0	5.0	5.0	15.0	3.0
T_2	5.0	5.0	5.0	15.0	3.0
T_3	5.0	5.0	5.0	15.0	3.0
T_4	5.0	5.0	5.0	15.0	3.0
T_5	5.0	5.0	5.0	15.0	3.0
T_6	5.0	5.0	5.0	15.0	3.0
TOTAL					