KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

KUMASI

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

FACULTY OF AGRICULTURE

DEPARTMENT OF HORTICULTURE

THE EFFECTS OF DIFFERENT LEVELS OF SUGAR AND SODIUM BENZOATE ON THE EXTENSION OF *Heliconia psittacorum* CUT FLOWERS

BY

SAMUEL KWASI OWUSU

APRIL, 2013

EFFECTS OF DIFFERENT LEVELS OF SUGAR AND SODIUM BENZOATE ON THE EXTENTION OF VASE LIFE OF Heliconia psittacorum CUT FLOWERS

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (MSC) DEGREE IN POSTHARVEST TECHNOLOGY)

BY

SAMUEL KWASI OWUSU

DECLARATION

I hereby declare that, this submission is my own work towards the degree of MSc Post Harvest Technology and that, to the best of my knowledge, it contains no material(s) previously published by another person(s) nor material(s), which have been accepted for the award of any other degree of the University, except where the acknowledgement has been made in the text.

Signature..... .....

SAMUEL KWASI OWUSU DATE

(STUDENT)

Signature:..... .....

PROF. (MRS) NANA SAKYIWAA OLYMPIO DATE

(SUPERVISOR)

Signature..... .....

MRS. HANNAH-VICTORIA ADZRAKU DATE

(SUPERVISOR)

Signature..... .....

DR. BEN K. BANFUL DATE

(HEAD OF DEPARTMENT)

DEDICATION

I dedicate this project to my family.

ACKNOWLEDGEMENTS

My greatest gratitude goes to the Almighty God for his guidance and protection. May his holy name be praised.

Again, I would like to appreciate the good works of my supervisors, Prof. N .S. Olympio and Mrs H-V. Adzraku and the entire lectures of the Faculty of Agriculture, KNUST, especially those in the Department of Horticulture.

My appreciation also goes to the Deputy Director General of the Council for Scientific and Industrial Research (C.S.I.R.), Dr.(Mrs) Mamma Entsua-Mensah and Director of (C.S.I.R.), Plant Genetic Resources Research Institute, Dr. L. M. Aboagye, and the West Africa Agriculture Productivity Programme (W.A.A.P.P.) Board for their assistance and kindness demonstrated to me during the period of my studies.

Finally, I would like to thank my parents, family members, colleagues, and everyone who helped in making this project a success, I say a big thank to you all.

.

ABSTRACT

Cut flowers are now becoming a major source of foreign exchange for some countries in the world. The vase life of these cut flowers has therefore become a major hurdle for these countries. The problem is how to increase the vase life of the cut flowers especially for export .The objective of the study was to determine sugar and sodium benzoate concentrations that could extend the vase life of one of the important cut flower materials, *Heliconia psittacorum*. Data on the number of days for cut flowers to change colour to brown, the flowers to drop down, as well as the flower head to bend and the flower stalk to change colour to brown were taken and used as a measure of vase life. The experiment was carried out in the laboratory of Horticulture Department, KNUST over a period of two and a half weeks, during which, the number of days for change to occur in any part of each flower were observed and recorded. The study revealed that preserving the cut flower in water gave a longer number of days in preserving the various parts of the cut flower than using sugar solution or sodium benzoate solution. The recommendation was that, economically, it is viable to keep cut *Heliconia psittacorum* flowers in water.

TABLE OF CONTENTS

CHAPTER 2

LITERATURE REVIEW

LIST OF TABLES

LIST OF PLATES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Introduction

Universally, flowers have been used as garden plants since the dawn of civilization. *Heliconia psittacorum* is grown for the florist trade as a landscape plant for, indoor and outdoor beautification, as well as for cut flower production.

Flowers beautify the environment in which they are found and they eloquently express the inexpressible (Vaughan, 1998) .With increasing affluence and cultural integration, flowers have assumed a more significant role in the lives of most people. Cut flowers now compete with jewellery as gifts on important occasions and are also used to decorate indoor environments. In most cases, a present of a bouquet is put in a vase and placed in a very conspicuous place to be seen and appreciated by on-lookers. Unfortunately however, these do not last for a long period.

The world flower trade has excellent prospects for cut flowers, cut foliage, live plants and bulbs, (Norman, 2004). The major markets for these products are usually the European Free Trade Area (EFTA), the U.S.A., Canada and Japan with major exporting countries being found in Latin America, the Caribbean and the Asian region. Recently, Africa has come into the scene with the emergence of eastern and southern African countries as major producers. Kenya is the largest producer of cut flowers in Africa (BDM 1994). By 1996, Kenya was the third largest world producer of cut flowers (Dawson, 1998). It is documented that the world market turnover of the flower sector is greater than the value of fruits and vegetables put together in monetary terms, (Norman, 2004). This demonstrates the magnitude of the market size which tropical countries like Ghana can take advantage of. This also means, the industry has a great potential to alleviate

youth unemployment and for the improvement of the economies of tropical countries such as Ghana.

Floricultural plants and products are therapeutic that is, they make people including the sick and recuperating patients feel happier and healthier when presented to them (Adzraku and Adjei, 2009).

The situation in Ghana on the other hand is less impressive.

Table 1: Statistics on Export and Production of flowers in Ghana

Year	No. of Products	No. of Exporters	Quantity in Metric tones	Value in Dollars($)	% contribution to export market
2000	1	3	54,917	113,520.11	0.15
2001	1	2	52,518	52,842.15	0.06
2002	1	2	13,337	14,824.35	0.02
2003	1	3	78,177	68,272.78	0.05

Source: Ghana Export Promotion Council/Data Processing Unit (2011).

Table 2: Statistics on export and earnings in Ghana

Year	Quantity in metric tones	Value in Cedi	Value in Dollars
2004	64,219	97,843,128	10,834
2005	237,987	143,691,968	157,470.72
2006	251,033	645,016,350	70,369
2007	109,208	476,458	506,271
2008	299,270	646,297	612,471
2009	273,659	1,207,644	845,808

Source: Ghana Export promotion Council/Data Processing Unit (2011).

Table 3: Cut flower Export to EU, USA and JAPAN

COUNTRY	YEAR							
	2010		2009		2008		2007	
	WEIGHT (KGS.	VALUE (US. $)	WEIGHT (KGS.)	VALUE (US. $)	WEIGHT (KGS.)	VALUE (US. $)	WEIGHT (KGS.)	VALUE (US. $)
E.U	422079	1784572	273515	843533	179169	603680	104103	488506
U.S.	787	2050	XXX	XXX	80	1200	XXX	XXX
JAPAN	XXX	XXX	XXX	XXX	17	10	XXX	XXX

Source: Ghana Export Promotion Council/Data Processing Unit (2011).

In spite of the fact that people enjoy the beauty and scenery of cut flowers, they do not last long. According to Adzraku and Adjei (2009), the beauty and attractiveness of cut flowers last for only two to three days under normal environmental conditions. This is because a flower detached from a plant is still alive due to the fact that it still undergoes certain metabolic process such as respiration (Blessington, 2002), therefore, when detached, and not given water and floral food it readily withers off and dies.

According to Harvey (1991), with reference to new varieties of flowers coming in from Thailand, established that the combination of these flowers with those that existed already had a positive influence on the marketability of the produce. In that case, these combinations provided an increasing need for long vase life. It is against this background that, the study was conducted to find a way to extend the vase life of cut flowers which ultimately will benefit the floricultural industry in Ghana.

1.3 Objective of the study

The objective of the study was therefore, to determine the concentration of sugar and sodium benzoate that can extend the vase life of *Heliconia psittacorum.*

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Senescence of cut flowers

Allaby (1998), defined senescence as the complex deteriorative process that determines naturally, the functional life of an organ or organism. Plant senescence is controlled by hormones. According to Alleyne (2000), cut flowers have a high surface area to volume ratio and as such they lose moisture readily than many perishable commodities.

According to Mayank (1987), senescence of cut flowers occurs through a sequence of changes involving the alteration of membrane chemistry, an increase in respiration, loss of membrane integrity and ultimately, excessive and irreversible water loss marked by wilting. Wilting of cut flowers is a typical indicator of the end of vase life Mayank (1987) and Harvey (1991).

Generally, senescence and wilting of the petals on a flower determines the longevity of the flower (Janick, 1979). Usually, the time between maturity to senescence and death is much shorter in petals than in leaves (Spencer and Titus, 1973;Lonati*et al*., 1972; Simon, 1967). Walhouse and Batt (1976) indicated that chloroplast degradation may be reversed up to a certain stage while petal senescence is an irreversible process.

2.1.1 Factors that induce senescence in cut flower.

Blessington (2002) stated that the factors that induce senescence in cut flowers were;

- Ethylene
- Plant hormones
- Micro organisms
- Cultural influences.

Gast(1997), also indicated that among the top ten reasons why flowers did not last in a vase

solution were; food depletion, attack by bacteria and fungi, normal maturation and aging, wilting and xylem-bruising and crushing, fluctuation in temperature during storage and transit, colour change (bluing) accumulation of ethylene, poor water quality, sub optimal cultural practices or conditions. Blessington (2002),listed the inability of the cut flower stem to absorb water due to blockage, excessive water loss from the cut flower, a short supply of carbohydrate to support respiration, diseases and ethylene gas as five of the most common reasons for early senescence.

2.1.2 The role of ethylene and other plant hormones in senescence.

Ethylene is a simple gaseous hydrocarbon, which is synthesized by all plant tissues and some micro organisms Jones (2001). It is represented by the structure C_2H_2.The author added that, It is a natural aging and ripening hormone released by ripening fruit, leaf and stem trimming and burning wood (Jones, 2001). It is physiologically active in trace amounts (0.1 ppm). Owing to the fact that ethylene gas is often released when plant produce is bruised or broken Faragher (2002) quality of such produce is usually reduced. Ethylene production in senescing flowers occurs in three phases, namely;

- A low steady rate
- An increase to the maximum
- A decline to a low rate(Blessington,2002)

The author did not observe ethylene release defects in foliage plants transported in sealed boxes without air exchange at 13^{o}c for 13 days. This indicates that foliage plants if not infected with disease pathogen or pests, or wounded/bruised do not produce considerable amount of ethylene during packing; the ethylene produced during packaging and the ethylene produced by plants during transportation are not harmful Blessington (2002)

2.1.3 Factors contributing to vascular blockage of xylem.

De Vries (1973) indicated that re-cutting of the base part of the flower stem under water restores the rate of water uptake. It was thus concluded that the main blocking occurred at the lower end of the stems notably, the cut surface and or inside the xylem elements. According to Lineberger and Steptonkus (1976), vascular blocking of roses has been shown to be caused by both micro organisms in the vascular system near the cut end of the stem and by gums higher up the stem. Blockage of water flow in cut flowers could also be due to an impermeable layer which may become deposited as a response to cutting Lineberger and Steptonkus (1976) Reduction of vase life of cut flowers by micro organisms was reported by Lineberger and Steptonkus (1976), the possible explanation offered for the action of micro organisms against cut flowers include bacterial plugging of flower vessel elements, enzymatic action or possible endogenous production of ethylene.

2.2 RESPIRATORY METABOLISM

According to Coorts (1973), the rate of respiration in many flowers rises to a maximum as flowers start to open followed by a gradual decline as flowers begin to mature from which point it increases dramatically over a relatively short period and finally declines. This second peak in the respiration drift is considered to indicate the final senescence stage (Coorts,1973).

The gradual decline in respiration in aging flowers may be caused by short supply of readily respirable substrates mainly sugars. It was therefore believed that the content of these substrates may indicate the potential life of the flower at a specific temperature, Nichols (1997). Supplying cut flowers with exogenous sugar maintains the pool of dry matter and respirable substrates especially in the petals, thus extending longevity, Coort (1973). Translocated sugars accumulate in the flowers increasing their osmotic concentration and improving their ability to absorb water

and maintain their turgidity ,Halevy (1976) and,Halevy and Mayank (1974).

2.3 COLOUR CHANGE

According to Paull *et al.* (1985), the spathe colour,spathe tissue, pH and ammonium ion concentration change simultaneously. The change in spathe colour in his experiment performed using anthodium var. "Ozaki Red" was the first visible sign of senescence and occurred shortly after respiration began to increase after the 8th day. The colour change observed was due to the development of a blue cast to the spathe, this colour change was also associated with an increase in total anthocyanins but the ratio of the two principal anthocyanins did not alter.Spathe tissue pH initially showed little change but then increased at about the same time that the spathe bluing was observed and it was also noticed that the ammonium ion in the spathe tissue showed a similar pattern.(Paull *et al*,1985)

2.4 Treatments to ensure vase life extension

2.4.1. Chemical treatments

Silver thiosulphate (STS) or silver treatment is used for preventing ethylene damage (Paull *et al*,1985). This is done by interference in the action of synthesis of ethylene by the flower. Silver thiosulphate is mixed in water and flowers absorb the solution. Its effect lasts for three days after harvest (Armitage,1994). Pulsing(putting the stems of a cut flower in a chemical/sugar solution) is a chemical treatment of flowers to prolong the vase life after picking, usually in a cool room for 12-16 hours, Armitage (1994) .According to Vaugham (1998),ethylene sensitive plants can have their vase life extended by about 75 percent, however, plants that are not sensitive to ethylene gas damage, for instance roses and carnations ,can have their vase life extended to 85 percent .STS and 5-10 percent sucrose solutions are chemicals often used for flower pulsing. These solutions are put in the holding water and the flowers are held at various temperatures for a specified period, .Perry (1998) The author also suggested a quick pulsing treatment at 25^{o}C-30^{o}C.Pulse treatments have however not been determined for many specialty cut flowers, Stevens and Gast,(1992)

2.4.2. Physical treatments

a) Temperature

Even though conventionally, flowers are harvested during cool periods of the day, they are still likely to contain high field heat. Temperature affects the rate of transpiration (water loss) from plants and therefore postharvest decline. Cooling the flowers reduces the field heat and thus reduces the rate of metabolic processes involved with senescence. However, the level of cooling has to be controlled because too low a temperature will result in chilling injury which is an adverse condition. According to Perry (1998), tropical flowers need a minimum temperature of 10^{o}C to avoid injury, while temperate flowers can be stored at temperatures as low as between 1^{o}Cand 4^{o}C Fluctuating temperatures during transport are one reason cut flowers may reach the market in poor condition, even though they may have been in a top-quality condition when packed. Small temperature loggers are therefore useful tools in shipments of flowers for export.(Perry,1998) According to Nowak and Rudnicki (1990), flowers will have to be pre-cooled in order to increase their post harvest life.

b) Storage Atmosphere.

Manipulation of atmospheric conditions can be used to extend the post harvest life of cut flowers. This can be done by (i) Controlled atmosphere (ii) Modified atmosphere and (iii) Low pressure storage, (Goszczynska and Rudnicki, 1998). The most commonly used of the three is the controlled atmosphere, which involves the regulation of mainly carbon dioxide and oxygen concentrations within the storage chamber.

2.5. EFFECT OF WATER ON VASE LIFE

2.5.1. Water quality

In general it is believed that distilled water gives higher vase life values than ordinary tap water. Tap water usually would contain different chemical compounds and may vary in pH, salinity and total dissolved solids which may negatively or positively affect vase longevity (Wolverton, 1996).

According to Wolverton (1996), chlorinated tap water could emit chloroform which could be harmful to the cut flowers placed in it. Additionally, ordinary tap water has the disadvantage of containing a lot of air, which blocks the xylem vessels in their transport of water. This can however be curbed by boiling the water to reduce the amount of air in it.

Halevy (1976) and Rogers (1973) both indicated the idea of an improved water status, which encompasses water that has been treated with mineral salts like *ammonium nitrate* (NH_4NO_3), *potassium chloride* (KCl) and *potassium nitrate* (KNO_3) and sugar. This improved water enhances longevity in that, it contribute to osmotic adjustment of the flowers and also reduces sensitivity to ethylene and equally promotes water uptake (Rogers ,1973).

Nowak and Rudnicki (1990) also identified sodium hypochlorite as a very effective compound for water disinfection. The compound releases free chlorine as oxidant upon contact with organic matter. This is used in a concentration of 0.005% / Litre of 10% solution per 2000 litres of water. This is useful especially in the storage of Gerberas (Nowak and Rudnicki ,1990). Chlorine treatment on the other hand, may cause brown spots on stems and cannot be used longer than a few hours. Another chemical identified for water disinfections is aluminium sulphate (Nowak and Rudnicki,1990). It is used in a concentration of 0.8g-10g per litre of water. This compound which is less effective than hypochlorite should however be changed every three to four days Nowak and Rudnicki (1990). A new method for disinfecting water is the use of ultra violet

radiation, whereby the water is filtrated to remove plant residues and other impurities and is then irradiated with ultra violet light, Nowak and Rudnicki (1990).

However, studies conducted on 16species of flowers at the University of Vermont in Australia in 2009, have shown that, there is no real difference between the use of tap water and distilled water (Han ,2009). The pH of water is however, important.(Han, 2009) Acidic water (pH 3.0-3.5) is best,as it deters the growth of micro organisms which clog plant stems. In addition, cut flowers take acidic water quicker, Han (2009). Stems of cut flowers tend to become blocked with bacteria and air bubbles. The use of clean containers and warm acidic water after cutting helps to reduce air bubbles, Faragher *et al (* 2002). The practice of re-cutting stems under water may not be needed based on a test of 3 species of flowers at the University of Vermont in 2009. It may however, be good insurance and can only help.(Han,2009)

2.5.2. Water uptake of cut flowers

To keep cut flowers beautiful for a longer time, the stem should be placed in water immediately, as air will rapidly move into the water-conducting tissues and plug the cell (Van Doorn,1997). Cuts can also be made under water to ensure that no air enters the stem. The rate of water uptake will depend among other things on the transpirational pull, the temperature, and the composition of the solution Van Doorn (1997).and Sacalis (1974) found that removing ions from tap water improved the rate of water uptake and delayed wilting in cut rose flowers. Tap water is often alkaline and it has been suggested that water uptake is reduced in such hard water Sacalis (1993). The rate of water uptake of freshly cut flowers may initially be high when the plant has a low water potential at cutting. The rate of uptake will reach a steady state corresponding to the rate of transpiration, but depending on the species, the rate may subsequently decrease Van Doorn (1997).

2.5.3 The use of preservatives

A floral preservative is a complex mixture of sucrose (sugar), an acidifier, an inhibitor, micro-organisms and a respiratory inhibitor. Sucrose serves as a source of energy to make up for the loss of functional leaves and ensures continued development and longevity of the flower. The acidifier also stabilizes the pigment and the colour of the flower, (Perry, 1998). This is why red roses turn blue when placed in water without a preservative or acidifier, (Perry, 1998). A microbial growth inhibitor is perhaps the most important floral preservative, Perry (1998). Bacteria and fungi are everywhere and are ready to enter the cut surface of the stem and multiply. Water transporting tissues can become blocked with micro organism, inhibiting water uptake. To aid floral preservatives in slowing down micro organisms, the vase/container should always be well cleaned to keep out micro-organisms. Water uptake is a major factor in keeping cut flowers fresh. A process called "hardening" ensures maximum water uptake, Perry (1998). Hardening, that is ,the placement of the freshly cut stem in 43.5^{o}c water (plus preservative) placed in a cool location for an hour or two would ensure maximum water uptake Perry (1998).Maximum water uptake is attained because water molecules move rapidly at 43.5^{o}C(Kinetic energy) and quickly move up the stem.(Perry,1998) Flowers stored in cool temperature lose little water, in one brief period while the water is cooling. Freshly harvested stems, leaves and flowers take up almost as much water as in the balance of their life,(Perry, 1998).

2.6 Cultural influences

Cultural practices have been observed to influence crop performance. This has been summed up by Blessington (2002) who states that "basically, those forces which improve crop fertility before and after harvest usually improve vase life" .Some of these cultural practices include time of

harvest ,mode of harvest, light, temperature after harvest ,humidity ,nutrition and pests and diseases.

2.6.1 Time of harvest of flowers

Longevity of some cut flowers is closely related to carbohydrate status at cut and thus flowers cut late in the afternoon last longer than those cut in the morning Roger (1962). This effect has been noted with leafy cut flowers such as rose but not with leafless ones like garbera. Flowers that lose water rapidly are best preserved when harvested early in the morning, after dew dries so that they do not stay wet and get infected with diseases, (Perry, 1998). Flowers at the earliest stage will ensure full opening and development with good quality in the vase. Flowers for domestic markets should be harvested at a more open bud stage than flowers that are destined for export, (Perry, 1998). Cutting flowers at the bud stage is advantageous as they are easier to handle and less susceptible to detrimental environmental conditions like high temperature and ethylene, Banden and Hannan (1972) ,Maxie *et al.* (1973;), and Nichols (1973). Some flowers are cut while still atthe bud stage or partly open in order to make storage, packing or transportation easier and to prolong market availability.

2.6.2 Mode of harvest

The mode of cutting does not generally affect the vase life of the flower if they are to be put in a solution of floral food straight after cutting. However, for best results the cut should be slanted and should be done with a sharp tool, Nowak and Rudnicki (1990). In certain cases some flower species exude sap from the cut surface, the latex exuded coagulates on the end, preventing water absorption. In such situations, the stem must be treated with hot water after re-cutting to circumvent the problem, Nowak and Rudnicki (1990).

2.6.3 Light

Light intensity is very important, for budded flowers, light is important in the opening of the flower buds and so would have an effect on the vase life, in that, flower buds closer to a permanent light source will tend to open faster than those far away from light(Nowak and Rudnicki,1990). Light intensity improves photosynthesis and hence carbohydrate storage in plants. When carbohydrates are low, respiration is very low and flowers senescence (deterioration) occurs. Therefore optimum light intensity during growth of the crop is very important to vase life.(Nowak and Rudnicki, 1990).

2.6.4 Temperature after harvest

Generally, the cooler the temperature the better for harvested flowers(.Nowak and Rudnicki,1990) Higher temperatures accelerate floral development and senescence. During hot periods of the year, crops sensitive to high temperatures have shorter vase life because flowers contain low carbohydrate levels. When the temperature is raised to an adversely high level to force earlier flowering, the same problem occurs. Lower temperature leads to a drop in the rate of respiration and utilization of carbohydrates. At lower temperature flowers produce less ethylene and also retard water loss and microbial development Blessington (2002).

Fluctuating temperature during transport is one reason cut flowers may reach market in poor conditions even though they have been in a top quality when they were packed. Small temperature loggers may help to determine when the temperature is getting too high; these are essential useful tools in shipment of flowers for export. To ensure a good quality vase life cool flowers rapidly after picking. Store them at low temperature between $1^{o}C$ -$4^{o}C$ (Perry, 1990).tropical flowers need temperature of $10^{o}C$ (minimum) to avoid chilling injury. (Perry, 1990)

2.6.5 Humidity after harvest

Increasing the relative humidity will reduce the rate of transpiration even though, it cannot be completely eliminated Blessington (2002). Under low humidity conditions, flowers lose water easily, leading to a reduction in their fresh weight. A loss of 10%-15% of fresh weight confirms wilting in flowers Blessington (2002). A water deficit will occur when the rate of water uptake is lower than the rate of transpiration. This is because water loss is faster through stomata than through the cuticle, the presence of stomata on the petals whether they are functional or not are relevant to the water loss and vase life of a flower (Van Doorn, 1997). Flowers with woody stems tend to need more water, to extend the vase life, there is the need to reduce water and maintain high R.H (95%-98%) in a cool room. (Blessington,2002)Under this condition, stems can be stored either wet (in buckets of water) or dry (wrapped and packed inside boxes) Blessington (2002)

2.6.6 Nutrition

Nutrition of a crop has an effect on its longevity, shortage or toxicities of nutrients that retard photosynthesis will reduce vase life.(Blessington,2002) Deficiencies in the number of nutrients, including Nitrogen, calcium, magnesium, iron and manganese, result in a reduction in the chlorophyll content, thereby reducing photosynthesis. The net result is a low carbohydrate supply to the flower. High levels of nitrogen at the time of flowering can have an adverse effect on maintaining quality (Novak and Rudnicki, 1990).

2.6.7 Pest and Diseases

Diseases and insect pests reduce the vigour of the plant directly by reducing the vase life indirectly, they reduce the vase life of plant by producing ethylene gas through injuring the tissue of the plant.

This hastens senescence and deterioration of the flower. Bacteria partially degrade cell walls or pit membranes by cellulolytic or pectolytic activity. The fragrant that accumulate results in an occlusion.

The inner walls of the xylem conduit are cellulosic in nature and the pot membrane is a remnant of the primary wall in which the matrix material is hydrolyzed during differentiation, leaving a cellulose microfibrillar web (Butterfied and Maylan, 1982). A major fungal disease that affects flowers is *Botrytis cinera (Butterfied and Maylan*, 1982).The spores are always present in the air and need the right amount of humidity and temperature to germinate (Vaughan, 1998).

2.7 Plant Material

2.7.1 *Heliconia psittacorum*

The common name of this flower is Parrot's Beak, Parrot's flower. (Armitage, 1994) It belongs to the plant family of Heliconiaceas. It is a perennial herb, native to the Caribbean, and the Americas. It is a small herbaceous upright plant often cultivated as a tropical ornamental plant and can grow up to a height of 1.2meters. The leaves may be between 15-100cm long and 6-20cm wide, they are oblong in shape, dark green and leathery. They are exotic plants which bloom abundantly all year round. The orange-red bracts arise from a central point on the stem. The long pointed leaves are shiny green with red edges. The orange-red flower bracts have a dark spot at the end. Parrot's flower is pollinated by humming birds, Wolverton (1996).The psittacorum are very suitable for cut flower arrangements Kroll (1995). The flower of the

Parrot's beak can last for one to three weeks in water Kroll (1995). The plant needs a lot of light , shade and a lot of water , but the soil should be well drained, rich and humid Armitage (1994) The flowers are erect, 9cm long with long bracts 3-15cm. They are orange and red in colour, at the top. The fruits are rounded 1cm wide, yellow to dark blue at maturity. They contain three seeds. There are many cultivars and hybrids of *Heliconia psittacorum*. The colour of the bracts varies from pale yellow or pink to pink red. The plant flowers after 3-4years of sowing Armitage (1994).

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1. Experimental site

The experiment was carried out at the Laboratories of the Department of Horticulture of the Faculty of Agriculture (latitude 06 43^{o}N and longitude 1 30^{o}W), KNUST, Kumasi between June 2011 and July 2011. .

3.2. Water treatment

Water used in the experiment was obtained from tap water from the Department of Horticulture which has its source from the Barekese dam. The water was used immediately it was fetched from the tap.

3.3. Flower vases

To ensure maximum sterilisation, flower vases were washed thoroughly with soap and rinsed with freshly boiled hot water which was hot enough to sterilize the vases but also could be handled

3.4. Plant material

The flower used in the experiment was from *Heliconia psittacorum*. The selection of the flower for the experiment was based on availability secondly it cultivated by flower producers as a cut flower. The material is even for export on a very small scale. The flower was obtained from the Department of Horticulture, Faculty of Agriculture, KNUST in Kumasi.

3.5. Methodology

The individual cut flower materials were carefully selected to ensure that all diseased parts were removed in order to prevent the possibility of having diseases affecting the results of the experiment.

To ensure that cut flowers stood well in the vases, without causing the vases to topple over due to an unbalanced weight they were cut to lengths longer than 30.0cm. While

the vases were made of plastic had a height of 22.0cm.

The re-cutting of the stems was done immediately the materials were brought from the field to minimize loss of water by transpiration and also to reduce respiration.

The cut ends were slanted to allow room for water infiltration into the stalk when it stood in the vase.

The cut was made as sharp as possible, avoiding any form of crushing of the xylem cell, which could lead to a blockage of the water path way into the stalk.

Isopropyl rubbing alcohol was used to clean the blades each time they were used on a different plant to avoid contamination.

The water was changed every 7 days.

The flowers were observed daily and the following signs of senescence were noted;

- Dropping of seed bract from the flower
- Wilting of the flower.
- Opening of flower bud.
- Tilting of flower head.
- Flower colour change to brown.
- Flower stalk colour change to brown.

3.6. Experimental design

Completely Randomized Design (CRD) with three replications was used for the experiment and the layout was as below.

Table 4: Experimental layout

	T1	T2	T3	T4	T5	T6	T7
R1	Wsb 500mg	Ws 20g	Wsb 750mg	Ws 30g	Wsb 250mg	WO	Ws 10g
R2	Wsb 750mg	NW	Ws 30g	Wsb 250mg	W0	Ws 10g	Wsb 500mg
R3	Ws 20g	Wsb 250mg	Wsb 750mg	Ws 10g	NW	Ws 30g	WO

Where "R" represents replication, "T" represents the various treatments used in the experiment.

In the experiment WO means one litre water only (control), while Ws 10g, Ws 20g and Ws 30g means the concentration of 10grams, 20grams and 30grams respectively of sugar solutions in a litre of water. On other hand, Wsb 250mg, 500mg and 750mg represent the concentration of 250mg, 500mg and 750mg respectively of sodium benzoate solutions in a litre of water.

3.7. TREATMENTS AND pH OF SOLUTIONS

The pH of the various solutions tested in the laboratory, showed that, the control experiment (only water) had the lowest pH of 5.78 while the 750mg sodium benzoate solution recorded the highest pH of 6.04. It was observed that, the pH increased as a result of increased in the concentration of the various solutions.

Table 5: Treatment and pH of solutions

Treatment	pH of solution
H2O only	5.78
H2O + 10g sugar	5.85
H2O + 20g sugar	5.85
H2O + 30g sugar	5.92
H2O + 250mg sodium benzoate	5.95
H2O + 500mg sodium benzoate	5.99
H2O + 750mg sodium benzoate	6.04

3.7.1. Vase life of *Heliconia psittacorum*

The vase life of the *Heliconia psittacorum* cut flower was considered to be over when the colour of the flower changed to dark brown, the flower head bent, the petals of the flower wilted or and fungi attacked on flower stems or there was a general loss of the aesthetic value and beauty of the flower.

3.7.2. The general vase life of bouquets (days)

The vase life of bouquets in each treatment was estimated by recording the least number of days taken by any of the cut flowers in the experiment to senesce. As indicated above.

3.7.3. Water uptake in millilitres (ml).

The volume of water in the vases was measured every 7days on two occasions. The difference between the initial (W1) and the final water (W2) levels in the vase was determined by subtracting the initial volume from the final volume. That is W_1-W_2= Amount of water taken up by cut flowers.

Where W_1=Initial amount of water in the vase (1000ml)

Where W_2=Final amount of water in the vase after 7 days.

3.8. EXPERIMENTAL SET UP

Plate 1a (1): T1 day 1

Plate 1b (2): T1 day 16

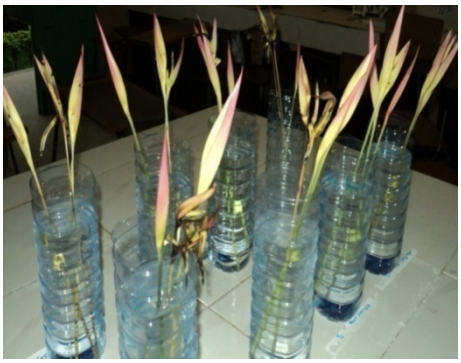


Plate 1c (3): T2 day 1

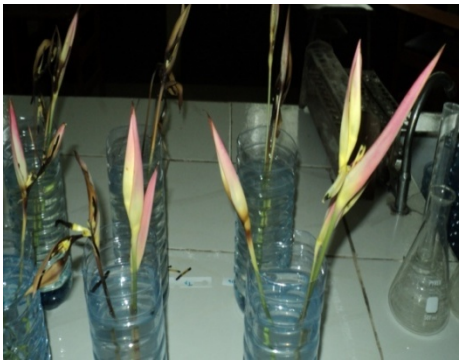


Plate 1d (4): T2 day 14

Plate 2a (1): T3 day 1

Plate 2b (2) : T3 day 10

Plate 2C (3): T4 day 1

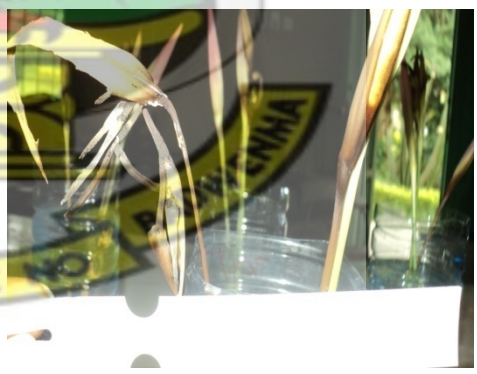


Plate 2d (4): T4 day 7

Plate 2e (5): T5 day 1

Plate 2f (6) : T6 day 5

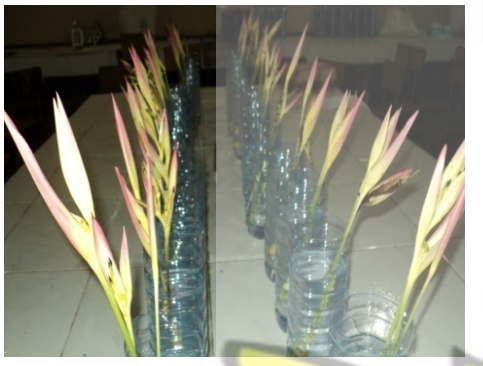


Plate 3a (1): T6 day 1

Plate 3b (2): T6 day 9

Plate 3c (3) : T7 day 1

Plate 3d (4) : T7 day 9

CHAPTER FOUR

4.0 RESULTS

4.1 Relationship between vase life and water uptake

Data collected on the vase life and water uptake by the cut flowers showed that, the flowers in the control experiment absorb more water than the other treatment while the flowers in the 750mg sodium benzoate solution absorb the least water.

Table 6: The Relationship between vase life and water uptake.

Treatments	Mean water uptake in milliliters (ml)
Water	350
Water+10g of sugar	300
Water+20g of sugar	300
Water+30g of sugar	200
Water+250mg of sodium benzoate	130
Water+500mg sodium benzoate	120
Water+750mg sodium benzoate	100

4.2 Analysis of Number of Days Taken for the Seed Bract to drop from the flower

From the ANOVA table it can be observed that the p-value < alpha, which means that at least one treatment recorded a different mean number of days for the seed bract to drop from the flower than the rest.

It took 6 days for the seed bract to drop from flowers in the control experiment as in the 30g sugar solution.

It also took three days for the seeds bract to drop from flowers when placed in 10g of sugar solution and 20g of sugar solution respectively. It took almost three days for the seed bract to drop from flowers when kept in 500mg of sodium benzoate and 750mg of sodium benzoate and almost six days in 250mg of the same solution.

Table 7: The Mean Number of Days for Seed Bract to drop from the flower

Table 7 indicates that, the experiment conducted in the laboratory showed that, the mean number of days that the seed bracts dropped from the flower was 6 days in the control experiment, and 30g sugar solution. While it took 2.67 days for the seed bract to drop from the 750mg sodium benzoate solution.

Table 7: The Mean Number of Days for Seed Bract to drop from the flower.

Treatments	**Mean Number of days for seed Bract to drop from flower**
Water	6.00
Water+10g of sugar	3.00
Water+20g of sugar	3.00
Water+30g of sugar	6.00
Water+250mg of sodium benzoate	5.67
Water+500mg of sodium benzoate	2.67
Water+750mg of sodium benzoate	2.67
HSD	1.053764

From the ANOVA table the p-value is less than alpha (P- value < alpha), which means that at least one treatment recorded a different number of days for wilting of flower from the rest.

Table 8: The mean Number of Days for Wilting of Flower.

Treatments	Mean Number of Days for Wilting of Flower
Water	15
Water+10g of sugar	15
Water+20g of sugar	6
Water+30g of sugar	6
Water+250mg of sodium benzoate	6
Water+500mg of sodium benzoate	4
Water+750mg of sodium benzoate	3
HSD	3.935115e-15

The cut flower in water only and 10g of sugar solution recorded the highest number of days (15) before wilting of the flower occurred while the 750mg of sodium benzoate solution recorded the least, i.e. 3 days

Table 9: The mean Number of Days for Full Opening of Flower Bud

Treatments	Mean Number of Days for Full Opening of Flower Bud
Water	3
Water+10g of sugar	3
Water+20g of sugar	3
Water+30g of sugar	3
Water+250mg of sodium benzoate	3
Water+500mg of sodium benzoate	3
Water+750mg of sodium benzoate	2
HSD	8.656395e-16

Table 9 shows that it took the cut flower three days for the bud to be fully opened when placed in all the solutions except the one placed in 750mg of sodium benzoate solution which took two days.

Table 10: The mean Number of days for the bending of flower head

Treatments	**Mean Number of days for bending of flower head**
Water	15
Water+10g of sugar	14
Water+20g of sugar	10
Water+30g of sugar	7
Water+250mg of sodium benzoate	11
Water+500mg of sodium benzoate	9
Water+750mg of sodium benzoate	9
HSD	3.955261e-15

From table 10, it can be seen that, the cut flower in water recorded the highest number of days before bending of flower head occurred, that is 15 days whiles that in 30g of sugar solution recorded a period of 7 days.

Table 11: The mean Number of Days for Flower Colour Change to Brown

Treatments	Mean Number of Days for Flower Colour Change To Brown
Water	16
Water+10g of sugar	14
Water+20g of sugar	10
Water+30g of sugar	7
Water+250mg of sodium benzoate	11
Water+500mg of sodium benzoate	9
Water+750mg of sodium benzoate	9
HSD	3.861606e-15

Table 11 shows that only water recorded the highest number of days (16) for the flower colour to change to brown while 30g of sugar solution recorded the least number of days (7).

From this table, there was no significant difference in the mean number of days between the treatments of 500mg and 750mg of sodium benzoate although the rest have significant differences in the means.

From the ANOVA table in the appendix two, it can be observed that our p-value < alpha, which means that at least one treatment recorded a different mean number of days for the flower stalk to change color from the rest.

Table 12: The mean Number of Days for Flower Stalk Colour Change to Brown

Treatments	Mean Number of Days for FlowerStalk Colour Change
Water	16
Water+10g of sugar	7
Water+20g of sugar	7
Water+30g of sugar	7
Water+250mg of sodium benzoate	10
Water+500mg of sodium benzoate	9
Water+750mg of sodium benzoate	7
HSD	4.535846e-15

Water only recorded the highest number of days (16) before the flower stalk changed colour, while 10g, 20g and 30g of sugar solution together with 750mg of sodium benzoate recorded a period of 7 days each.

From this table, there is no significant difference between the mean number of days of 10g, 20g of sugar solution and 750mg of sodium benzoate solution in the colour change of the flower stalk.

CHAPTER FIVE

5.0 DISCUSSIONS

The vase life of cut flowers represent the potential useful longevity of the flower at the final consumer's home, (Halevy and Mayank, 1979), and generally, the senescence and wilting of the petals determines the longevity of the flower, (Halevy and Mayank, 1979). In the current study, sugar and sodium benzoate solutions applied at different concentrations, could not extend the vase life of *Heliconia psittacorum*. Although supplying cut flowers with exogenous sugar has been shown to extend longevity (Coorts 1973, Rogers 1973). Results obtained in the current study does not support this observation.

The two different solutions, that is, sugar and sodium benzoate at different concentration levels of 10g, 20g and 30g, for sugar and 250mg, 500mg and 750mg for sodium benzoate were used in experiment. However, these results differ from reports by (WEI Xiu-jian et al 2008) where 500mg/L sodium benzoate was found to be more effective in the preservation of *paeonia lactiflora* cut flowers.

Preservation of cut flowers with sugar solution at 10g/L was reported to extend the shelf life of cut flowers by (Marinelli, 2009). The result was comparable to the experiment conducted at the Horticultural Laboratory at KNUST where 10g/L sugar solution kept the flowers up to 15 days. This treatment lasted longer after the control experiment. On the contrary, 20g/L sugar solution that (SHEN Yu-hua *et al* 2009) observed to give a longer shelf life to cut Lilies resulted in a vase life of only 10 days in the present study.

It was also observed that, the pH of the various treatments increased with an increasing concentration of the sugar of the various solutions. For instance, the control treatment had a pH of 5.78 while 10g/L sugar solution recorded a pH value of 5.85 as against 250mg/L sodium benzoate solution which recorded a pH 5.92. One key ingredient in a preservative solution that

is critical for the handling of field-grown cut flowers is the pH of the solution, (Han, 2010). It has been shown that low pH (pH=3.5) liquids travels faster in the water-conducting system (xylem), (Han, 2010), thereby preventing or reducing wilting that frequently occurs in field-grown cut, flowers. The results of current study, conducted at the Horticultural Laboratory at KNUST, where high pH values of solution of 6.04 could not extend the vase life of cut *Heliconia psittacorum* beyond 9 days as against a pH of 5.78 which extended the vase life up to 16 days.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY

Sustainable exporting of flower products is of utmost importance to the government of most African countries including Ghana. This enables the country to obtain additional revenue and also create employment for the youth. Ghana cannot continue rely only on exporting of traditional crops like cocoa and coffee. Flower products exported in the year 2000 accounted for 0.15% of the export commodities in that year and amounted to 113,520.11 while 845,808 were accounted in 2009. With the increasing affluence of the modern society, flower and flower products are therapeutic, which make people including the sick feel happier and healthier when given as a gift. Flowers now compete with jewellery on important occasion as a gift. In order to achieve the object of growing and exporting more flowers, there is the need to research into how to extend the vase life of cut flowers. This will enable Ghana to obtain the benefits of flower export than Kenya, as Ghana stands to benefit from vicinity advantages of freight to Europe and America. The research conducted revealed that water only could extend the vase life of cut *Heliconia pssitacorum* flowers up to 16 days. There is the need for further research into the possibility of extending the vase life of cut flowers for the benefit of Ghana.

6.2 CONCLUTION

From the experiment carried out, notable findings were that, the control experiment had the highest mean number of days for the seed bract to drop than all the other treatments except the 30g of sugar solution. Again the control treatment had the highest number of days, that is 15 days for flowers to wilt and bent, and 16 days for the flower colour and stalk to change to brown. On the other hand, 20g and 30 g sugar solutions had 6 days while 750mg sodium benzoate had 3

days for flowers to wilt. There was a positive correlation between increasing both the sugar and sodium benzoate contents and the pH values of the solutions. The average water uptake of the vases decreased as the pH of solution increased.

6.3 RECOMMENDATION

Observations made during the experiment and references made from the results indicate that, it is economically viable to preserve the cut flower of *Heliconia psittacorum* with water only and 10g of sugar solution, since sodium benzoate and other levels of sugar resulted in keeping the cut flower in lesser days. *Heliconia psittacorum* posses great potential in the future of cut flower export business in Ghana and therefore, it is recommended that further study be done on this flower to ascertain practices that will give a longer vase life and thus best the time of air freighting and handling.

REFERENCES

Aarts J.F. TH (1957) Over de handbaarkeid van snijbloemen.Neded van de landbouwhogesschool le Wageningen.

Allaby M, (1998)-Dictionary of plant science. Oxford University Press

Alleyne J.C. (2000) Caring for cut flowers. Retrieved from http://www.blossomscellan.com/caring for fresh cut flowers htm (Nov 21,2011)

Armitage A.M. (1994) Ornamental bedding plants.*CAB International*

Armitage, A.M. (1993) Specialty cut flowers, the production of annuals, perennial, bulbs and woody plants for fresh and dried cut flowers, Timber Press/Varsity Press.

Adzraku H.V. and Adjei P.Y. (2009) Special Topics in Floriculture. IDL Lecture material

Blessington T.M. (2002) Post Harvest handling of Cut flowers. *UniversityofMaryland.www.sydneyflowers.au*

Biotechnology and Development Monitor (1994), Kenya cut flower booming Hort. Science, No. 20.vol.32 pp. 6-7

Barden, l. E. and Hanan, J.J. (1972), Effect of ethylene on carnation keeping life. *Amer.Soc.Hort.Sci 97:785-788*

Butterfield, B. G. and Meylan, B. A. (1972), Cell wall hydrolysis in the tracheary element of the secondary xylem 71-84, in P Baas P(Ed) New perspective in wood anatomy.

Coorts, G.D. (1973) Internal Metabolic Changes in Cut flowers. Hort. Science 8:195-198

Dawson P. (1998)-Kenya flowers power. Vol. 129 No.9 Grower.

De Vries, D.P., (1973). Selection of hybrid tea-rose seedlings for cut flower yield. Euphytica, 25:361-365

Faragher, T.,Slater,T. and William, V. (2002) post- harvest handling of Australian cut flowers. Rural industries research and development corporation publication, Australia

Gast, K.L.B. (1997), Commercial specialty cut flower production. Kansas State University.MF-2261

Goszczynska D.M. and Rudnicki, R.M. (1988) Storage of Cut flowers. *Horticultural reviews.10, 35-64*

Halevy A.H. (1976) Treatments to improve water balance of cut flowers.*Acta Hort 64:223-230*

Halevy A.H. and Mayank, S.(1974) Improvement of cut flowers quality, opening and longevity by pre-shipment treatments. *Acta. Hort. 43:335-347*(I), Horticultural reviews(ed. Janick, J.),1:204-236J.

Han, S.S.(2004).Sugar and Acidity in preservative solutions for field-grown cut flowers.

Harvey E.C. (1991).Opportunities and constraints to the production of cut flowers and ornamentals. Post harvest management of tropical fruits and ornamentals in the Caribbean region; *CTA-seminar proceedings*

Janick, J. (1979) Senescence and post harvest physiology of cut flowers, part 1 Hort. Reviews Vol. 1.

Jones, R. (2001) Caring for cut flowers. Second edition Land links Press, Collingwood, Victoria, Australia

Kroll R., (1995) Cut flowers. Macmillan Technical Centre for Agriculture.

Lineberger D.R. and Steptonkus P.L. (1976), Identification and localization of vascular occulusions in cut Roses J.Amer.Soc.Hort.Sci.101

Lonati I, C. Vanloorn, and J. Bruinsma (1972) Effects of auxin on the activity of RNA hydrolyzing enzymes from senescing and aging barley leaves.67:146-154.

Marinelli, K. (2005) Fresh cut flower preservative packets. Retrieved from http://ezinearticles.com/?Fresh-cut-Flower-Preservative-Packets&id=81863 (November 21, 2011)

Maxie, E.C. Farnham, D. S., Mitchell, F. G., Sommer, N. F. (1973) Temperature and ethylene effects on cut flowers of carnation. *J. Amer. Soc. Hort. Sci. 98:568*

Mayank, S. (1987) Senescence of cut flowers *Hort. Science 22:863-865*

Nichols, R . (1973), Senescence of cut carnation flower: respiration and sugar status. J. Hort. Sci.

48:111-121

Norman, J.C.(2004). Tropical Floriculture. National Science and Technology press, Accra, Ghana

Nowak, J. and Rudnicki R.M.,(1990).Post-Harvest handling and storage of cut flowers, florist greens potted plant .*Chapman and Hall*.

Paull, R. E., Jung Chen N , and Deputy, J. (1985) Physiological changes associated with senescence of cut anthurium flowers. Journal of the American society for Horticultural science 1210:156-162.

Perry, L.P., (1998).Herbaceous perennials: A guide from propagation to marketing. NRAES-93. Northeast Refinal Agricultural Engineering Service, Ithaca,N.Y.208pp.

Rogers, M.N. (1973), An Historical and critical review of post –harvest physiology research on cut flowers. *Hort .Sci*.7:*57-59*

Rogers, M .N. (1962)Sell flowers that last.(Report of nine papers)Flor.Rev .130-131

Sacalis, J. N. (1974) inhibition of vascular and extension of vase life in Cut roses with and ion exchange column. Hort Science 9:149-151

Sacalis, J .N., (1993).Cut flowers: prolonging freshness, Post production care and handling (second edition) Ball Publishing, Batavia 11.

Shen Yu-hua, DUAN Yung-ping, QIAO Yuan and ZHANG Jiao (2009) Effect of sodium benzoate on cut Lily flower fresh keeping. Northern Horticulture 2009.Retrieved from http://en.cnki.com.cn/Article en/CJFTOTAL-AHNY200812072U(November 2011)

Simon, E.W. (1967), Types of leaf senescence.Symp.Soc.expt.boil.Cambridge*21*:*215-230*

Spencer, P.W. and Titus J.S.(1973),Apple leaf senescence:leaf disc compared to attached leaf. Plant physiology 51:89-92

Stevens,A.B. and Gast, K.L.B. (1992) specialty cut flowers. A Commercial Growers Guide. Cooperative Extension Service, Kansas State University 1034:11.

Van Doorn W.G. (1997),Water relations of cut flowers Horticultural reviews, Vol. 18,edited by

Jules Janick.

Vaughan, M.J. (1998). Cut flower care *Timberpress, Portland Oregon.*

WEI Xui-jian ,LI Ya-li, FAN Mei-hua(2008)(College of life science, Liaocheng University, Liaocheng,Shandong 252059)Effect of salicylic acid on Water Metabolism and Vase life of the peony cot flower(J);Journal of Anhui Agricultural Sciences, 2009-28

Wollhouse, H.W and Bast, T. (1976), The Nature and Regulation of senescence in plastids. Horticulture reviews 1:163-176.

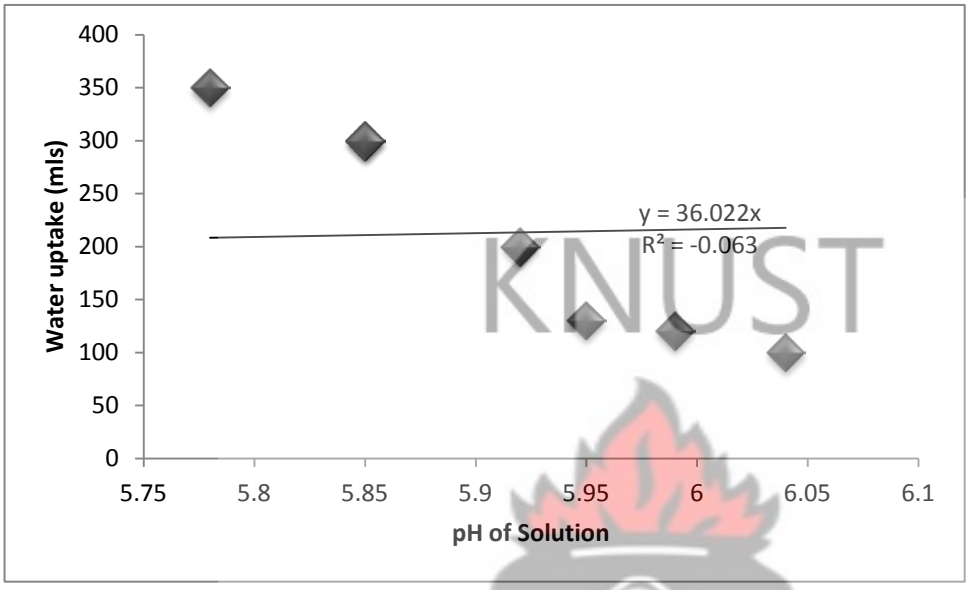
Wolverton, B.C.(1996).Co. friendly House plants Weidenfied and Nicolson, Ltd,London.

Zagory ,D. and Reid,M.S.(1986).Evaluation of the role of vase microorganisms in the postharvest life of cot flowers. Arta Hort.(ISHS)181:207-218

APPENDICES

APPENDIX One

GENERALISED LINEAR REGRESSION MODEL FOR TREATMENT



APPENDIX Two

The following are the results of the experiment.

Treatment code	Interpretation
Water	Water (control experiment)
Water10S	10g of sugar solution
Water20S	20g of sugar solution
Water250SB	250mg of sodium benzoate solution
Water30S	30g of sugar solution
Water500SB	500mg of sodium benzoate solution
Water750SB	750mg of sodium benzoate solution

Table 4: ANOVA Table on the Number of Days taken for the Seed Bract to drop from the flower

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	48.571	8.0952	56.667	5.077e-09 ***
Residuals	14	2.000	0.1429		

Alpha = 0.05

Table 5: ANOVA Table on Number of Days for Wilting of Flower

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	452.57	75.429	3.7862e+31	< 2.2e-16 ***
Residuals	14	0.00	0.000		

Alpha=0.05

4.3 Analysis on Number of Days Taken for Full Opening of Flower Bud

Table 6: ANOVA Table for Number of Days for Full Opening of Flower Bud

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	2.5714	0.42857	4.4456e+30	< 2.2e-16 ***
Residuals	14	0.00000	0.0000		

Alpha=0.05

4.3 Analysis on Number of Days Taken for the Tilting of Flower Head

Table 7: ANOVA Table for Number of Days Taken for the Tilting of Flower Head

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	148.29	24.714	1.228e+31	< 2.2e-16 ***
Residuals	14	0.00	0.000		

Alpha=0.05

4.4 Analysis on Number of Days Taken for Flower Colour Change To Brown

Table 16: ANOVA Table on the Number of Days Taken for Flower Colour Change To Brown

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	176.57	29.429	1.534e+31	< 2.2e-16 ***
Residuals	14	0.00	0.000		

Alpha = 0.05

4.5 Analysis on Number of Days Taken Flower Stalk Colour Change

Table 8: ANOVA Table for Number of Days Taken for Flower Stalk Colour Change

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treat	6	198	33	1.2468e+31	< 2.2e-16 ***
Residuals	14	0	0		

Alpha = 0.05