MAKERERE UNIVERSITY

COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

SCHOOL OF AGRICULTURAL SCIENCES

VASCULAR TISSUE AND CELL DYNAMICS DURING BENT NECK FORMATION IN SWEET HEART AND INTERMEDIATE ROSES

BY

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DECLARATION

I DRANI MOHAMMED declare that this report is my original work and has not been presented for the award of a degree in any other University or any other award.

SIGNED .... DATE 23/02/2021 ....

DEDICATION

This report is dedicated tomybeloved late dad JumaAligo, diligent mum TikoKemisha, lovely step motherDipioAfisa, not forgettingChandiru Halima, relatives, friends and the den of course mates in the struggle.

APPROVAL

This special project report has been submitted for examination with my approval as Makerere University Supervisor.

Signed.. Date...23/02/2021...

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ACKNOWLEDGEMENT

I understand the greatness of Allah the Mighty, He provides to those who are committed what they deserve. I would wish to surrender my sincerity to Dr. R C.O.Okello who with all the integrity and sufficient knowledge supervised me to destiny of this work. I want to recognizeDr.MildredN.O.Ssemakula for her mentorship and I loved the excellent support from Dr. Muyombiya George William the chief technicianBio-molecular Resources andBio-laboratory Services at College of Veterinary Medicine, Animal Resources and Bio-Security (COVAB) MakerereUniversity. Special thanks toMr. Anthony (the production officer Jambo roses), Mugisa, Ti'bo, and all the technical staff in the greenhouses for the diligent service rendered to me.

ABSTRACT

Rose plants are ornamentals most selling in the world market. Bent neck Peduncle phenomenon (BPP) compromises their quality. The objective of this study was to explain the basis for the high prevalence of bent neck in sweet heart roses and old plants at the vascular tissue and cell level. It was hypothesized is that bent neck formation is1) caused by large flower bud weight that becomes too heavy for the stem to withstand, 2) prevalent in rose cultivars with large bud weight to neck diameter ratio, and 3) due to non-uniform cell division and expansion around the neck region of the flower stem. Treatments considered were cultivar, age and cultivar group (intermediates and sweet hearts). Data was collected on stem length, neck diameter, bud weight and Internode number. Key results were that BPP occurred in all the cultivar groups. Neck diameter in the bent neck was found to be thinner than of the normal neck. Stem length in bent necks were shorter than in normal necks but not much different in comparison of individual plants other than Akito with the smallest length while the cultivar groups had similar stem lengths. Neck diameter of the bent was smaller than in the normal neck and much smaller in the sweetheart relative to intermediate cultivars.

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ABBREVIATIONS AND ACRONYMS

EHPEAEthiopian Producers of Horticultural Products Association

USAUnited States of America

CaCalcium

NAANaphthalene Acetic Acid

EUEuropean Union

BPPBent Peduncle Phenomenon

ANOVA Analysis of Variance

COVABCollege of Veterinary Medicine, Animal Resources and Bio-Security

LSD Least Significance Difference

BBS Bio-molecular Resources Bio-laboratory Services

CHAPTER ONE: INTRODUCTION

1.1Background

Roses (Rosa hybrida L.) are one of the most important commercial crops grown for different purposes such as pot plant, garden plant and cut flowers (Azadi et al., 2007). Among all other cut flowers, roses lead in popularity because of their beauty, fragrance and long lasting blooming qualities (Ghaffoor et al., 2000; Tabassum et al., 2002). Ethiopia has an ideal production climate for cut rose production. The floriculture sector had shown a very dramatic growth in Ethiopia, even surpassing most African nations that have an established operation long before Ethiopia started growing flowers(De, 2010)

Rose production in Ethiopia has shown remarkable growth over the past decades. 80% of the existing flower farms are producing rose flowers. Consequently, the country's export volume rose rapidly and in no more than 7 years Ethiopia became the second largest flower exporter in Africa (next to Kenya) to the European Union (EU) market (Gebreeyesus and Sonobe, 2009). Rose cultivation techniques underwent evolution in the late 20th century. Shoot bending growing technique was progressively replacing the traditional upright growing technique in greenhouse production. This new technique posed new challenges to both cultivation and research (Sarkka, 2004).

In Uganda, floriculture sector is one of the top ten foreign exchange earnings, contributing closely to $57 million in export revenue. The floriculture industry which largely produces roses and cuttings began to take off in the early 1990s but remains at an early stage of development. It is also such a small sector made up of about 20 flower farms with coverage of about 250 hectares. The farmers grow flowers in custom built greenhouses and the flower sector is employing about 4000 people. Most flower farms are located near the shores of Lake Victoria because of fresh good quality water availability throughout the year. This also creates an advantage of being near Entebbe international airport as flowers on export areairtransported. The quality and vase life of cut flowers is greatly affected if pre-harvest factors are not properly monitored and controlled (Zaky, 2013). Cut flower quality is also affected byboth macro and micro plant nutrients. Some quality disorders happen even before harvesting the flower for instance blind wood, bull heads, color fading and bent neck. Bent neck is common in rose plants; that has been known and researched about as a post-harvest physiological disorder. Studies show that bent neck in cut rose flowers is caused by pre-harvest factors such as time of harvesting. That is flowers harvested at a more mature stage will not wilt as quickly compared to flowers harvested prematurely. If water balance is not maintained between water uptake and transpiration, the stem of cut rose flower will bend at the peduncle, more so when vascular occlusion occurs(Doom, 1993). The degree of susceptibility to bent-neck varies among cultivars with Sweetheart roses most vulnerable in Uganda according to research.

1.2 Challenges in production of roses in Uganda**.**

Uganda, flower farms are shifting from growing cuttings as opposed to cut rose flowers. A preference to cuttings emerged following financial challenges of the cut flower industry over the past years. Moreover, Uganda's climatic conditions are more suitable for cuttings and so have facilitated the continued growth of cuttings business. Consumers and producers have preferences for intermediate and tea hybrid roses because of their good prices thisis a challengeto Uganda in the World flower market since it majorly produces sweetheart roses. Government of Uganda has less intervention with incentives, like investment loans with low interest rates, tax holidays, and subsidized air freights to the industry. Electricity bills are averagely high being between shs10-30 million a month said by Musoke, 2018 this makes the industry uncompetitive since quality management through cold chain is truss without electric power. Several other factors including, cultivars and proper choice of greenhouse cladding material, bad roads, however, the degree of susceptibility to bent-neck varies among rose cultivars.

1.3 Problem statement:

Bent neck is prevalent in sweet heart rose plants and their occurrence tends to increase with plant age. However, bent neck formation in stems growing on rose plants has not yet been explained at the stem, vascular tissue, and cell level.

1.4 Justification of the study

- Findings from this study will be useful to breeders working towards the elimination of bent necks in lines that may be having novel quality traits

1.5 Objectives of the study

1.5.1 General objective:

The objective of this study was to explain the basis for the high prevalence of bent necks in sweet heart roses and old plants at the stem, vascular tissue, and cell level.

1.5.2 Specific objectives:

- To determine the relationship between flower bud size and stem size in rose stems with bent neck,
- To determine the relationship between bent neck formation to the phloem thickness and xylem diameter, and
- To determine the relationship between bent neck formation to the number and volume of cells around the neck region of the stem.

1.6 Hypotheses

My hypotheses were that;

- Bent neck formation is because rose flower bud weight becomes too heavy for the stem to withstand.
- Bent neck is prevalent in the rose cultivar with large bud weight to neck diameter ratio
- Bent neck formation is due to non-uniform cell division and expansion around the neck region of the flower stem.

CHAPTER TWO: LITERATURE REVIEW

2.1Background

Roses (Rosa hybrida L) have lasted in history, cultivated as ornamentals for over 2,000 years. Roses since the time of Chinese dynasties (141-87 BC) have been in cultivation and were common in the gardens of the imperial palace as wild roses. In the historical ancient times, importance of roses was proven by rose diagrams in the ancient Chinese paintings, pottery and books.1792 was the time Chinese roses were introduced in Europe and their importance traced back to the Renaissance reflected by European paintings (Guoliang, 2003).

Intensive programs of breeding after the year 1800 which focused majorly on garden, cut flower, house plant (pot roses), medicinal use of roses and oil production from roses resulted in to dramatic increased cultivation of roses. Several European countries like Germany, Italy and France where the climate favored cultivation made it possible to have started outdoor growing of cut roses. Thereafter, modern cut flower industry was set in Holland in 1896 when the first greenhouse was constructed. Short lived cultivars were produced which targeted the local markets and the industry rapidly grew, expanded up to 16 European countries and even the USA.The quality of the roses rapidly increased due to extensive testing of new cultivars. Later, vase life and productivity started to increase due to improved breeding techniques that were used intensively in the 1950’s (Marriott, 2003). All these years of selection breeding focused on traits of high productivity, long vase life and novel (newly made) colors. Fragrance was not in the list of most desirable characters and consequently only a few cultivars were highly fragrant (Marriott, 2003).

Rose growing business had made clear distinctions between small and bigbudsize roses, and vital was also the length of the stem which depended on the rose family and species. Stem length was a factor mainly influenced at harvest, based on the physical possibilities and the target set by the rose grower. Though it was a rule that bigger bud was proportional to longer stem size ensuring higher prices in the market, yet it was very hard for many varieties to give that difference between big and small bud rose(De, 2010).

Substrate and open soil are the methods common in cultivation. The substrate is made from different materials with Coco peat (waste product of palm tree) and Rockwool (whim stone). According toDe, (2010), substrates are free of nematodes and other microbes in the soil and have a known p^H close to 5.5 which is in the agricultural range. In case of alkalinity treat substrate with acid and in the normal soil, rootstock obtained from a wild rose bush preferable because it is resistant to nematodes, fungi and other pests.

Treatment at Pre-harvest and postharvest in rose flowers impacted on postharvest longevity and other related characteristics. “Grand prix” cut roses treated with Calcium (Ca) and Naphthalene Acetic Acid (NAA) at pre-harvest plus(+) either Florissant-400 or Silicon at postharvest significantly prolonged vase life which also increased the percentage of flower opening and uptake of rose cut flowers.Ca+NAA at pre-harvest +Florissant-400 had a superior effect on extending of flower life, increased flower diameter(cm) and it’s fresh weight percentage(Zaky, 2013).

Bent neck is an occurrence where flower peduncle curves. It compromises rose flower quality attributes like; Velvety (thick short pile) petal texture, Rich and varied flower color, Rich sweet scent/fragrance, Profusion/abundance of bloom and Longevity of shelf life Bent neck phenomenon is variant among cultivars but more prevalent in old, sweetheart and intermediate rose plants.

In roses Bent Peduncle Phenomenon (BPP) is a common characteristic resulting in the production of abnormal flowers and their rejection by rose farmers.BPP occurrence is depended on cultivars and environmental conditions. Bending of flower peduncle in a greenhouse is common in young plants of about 3 years below and in period of accelerated growth(Zaccai et al., 2009). Traits associated with BP among others include; phylloid structure, stem fasciations (ribbon-like flattening normal cylindrical peduncle), abnormalities in the sepal pattern, the schelerenchymal tissues of BPP stems exhibited larger cells and thinner cell walls than of the normal stem(Zaccai et al., 2009).

2.2Production of Roses

2.2.1 Production at Global level

The only high income country among the top five World producers of flowers according to UN comtrade, (2014) is Netherlands. It's the World's largest exporter of cut flower with 52%, Competitions are coming from Columbia with 15%, Kenya 7%, Ecuador 9%, and Ethiopia 2%(International, 2015). According to Flora Holland, (2014), Columbia was leading in global cut flower trade by sea container in 2013. World production has shifted to Southern Hemisphere associated to favorable climate, land availability, cheap labor, and improved logistics and water being plenty.

2.2.2 Production in Uganda

Floriculture sector contributes close to US$30 million in export revenue. It expanded to 192.1 hectares in 2009 and now investments in the sector stand at over US$54 million employing 6,000 People (UIA, 2009). The sector produces over 40 varieties mainly roses (70%). Flower farms are mainly established around the shores of Lake Victoria at Mpigi, Wakiso and Mukono(central Uganda), South Western Uganda at Ntungamo and Eastern Uganda at Kapchorwa. The volumes and values of flower export have increased from 3,000tonnes worth US$14.61 million in 2000 to 5,349 tons worth US$29 million in 2008. This placed Uganda among the top five largest exporters of cut flowers in Africa. The floriculture sector is very well regulated towards meeting the highest European product safety and quality standards ensured by landmark regulatory frame work, Uganda Code of Practice for the Horticulture sector which specifies strict guidelines for farmers and the managers to allow for rational attainment of high quality flowers for export.

2.3Propagation and propagation methods

2.3.1 Propagation

Rose plants can be grown on own roots or rootstock. Use of rootstock increases flower production, improves flower quality, increases resistance against drought, pests and diseases, promotes continuous harvest possibility and ensures buffer potential against differences in the environmental conditions.

2.3.2 Propagation methods

2.3.2.1Cutting

This method is where ripe flower stem and/or blind flower stem is rooted and grown into a new plant. Important to consider is stem ripeness because soft wood is susceptible to rotting and shoot or bud with 5(five) leaflet leaf to promote faster growth.

2.3.2.2 Tissue culture

This is a micro-propagation technique which involves rapid and prolific production of novel traits of interest from young plant tissues in a sterile condition. Hence plants are pest and disease free, uniform and vigorous growing.

2.3.2.3Stenting

This method involves placing the scion with one 5(five) leaflet leaf on an un-rooted rootstock, where rooting and graft union occur simultaneously.

2.3.2.4: Grafting

This is the art and science of creating union between the rootstock and the scion. Recommendations are that media heating should be possible, temperature should be kept at 28 to 30 ^{0}C, relative humidity (RH) be at 95%, well established root system of rootstock is vital. Three grafting techniques are the main valued in rose plants.

- Micro-budding; a bud cut from the scion is fitted in to replace a bark removed from the rootstock and firmness is provided by wrapping using a plastic tape.
- T-budding; in to a T-shaped cut on the bark of the rootstock you insert a cut bud from the scion and cover it with a plastic tape.
- Split grafting; rootstock and scion must be about 5 mm diameter. Make a slant cut on the rootstock at an angle of about 30 ^{0}C at least two nodes above the ground. Shape the scion base to fit the slant cut made on the rootstock. Make sure cambium of the rootstock and the scion are completely in conduct.

2.3.2.5: 0.5/1.5 year's bushes/ plants.

T-budding is used and covered with plastic tape. Grafting is done on to rootstock in open field and graft union formation occurs in about 3Weeks. Rootstock bush is then removed to allow scion to grow to a shoot height of 10 cm before transplanting is implemented. Plants are productive in 3 to 4 months.

2.3.2.6: Dormant eyes

This technique has similitude of 0.5/1.5 years bushes/plants but the scion in it remains dormant because the rootstock bush is not removed to allow shoot growth. Plants are productive after 4 to 6 months.

2.4: Planting and management of rose plants.

2.4.1: Planting

Most commonly used method is bending system. There are double rows per bed. A spacing of 20-30 cm between rows and between plants, 85-100 cm spacing is kept between beds with 6(six) Plants per meter squared.

2.4.2: Management

- Greenhouse considerations
  - ✓ Maximum light transmission implying that choose the correct gladding material.
  - ✓ Gutter height of about 4.5 m is appropriate in Uganda
- Other Installations
  - ✓ Screens can be automatic or use shade nets or white wash.
  - ✓ Established source of Carbon dioxide can be distributed using installed fans and delivery tubes.
  - ✓ Heating and assimilation lights become necessary in temperate regions.
  - ✓ Use sulphur burners to prevent mildew
  - ✓ Fertigation system is a must to enhance nourishment in plants.
  - ✓

2.5: Soilless cultivation

This is where growing techniques are applied in artificial conditions to say use of organic or inorganic substrates instead of soil as a media. This ensures precision of watering and nourishment which can be through hydroponics of open cycle or closed cycle.

2.6: Plant establishment

2.6.1: Pinching

This is removing of flower bud to stimulate bud break done at the first 5(five) leaflet leaf. Pinching can be

- ✓ Soft pinch; bud removed is less than a pea size. It is a quicker method to carry out but few bud breaks.
- ✓ Hard pinch; here bud removed is greater than a pea size. The process is slow but more bud breaks.

2.6.2: Pruning

- ✓ Harvesting as a form of pruning is normal done at the first 5(five) leaflet leaf so that the plant grows taller with time.
- ✓ An under hook cut; cutting old stems to allow rejuvenation of new shoots from the bottom/ knuckle.

2.6.3: Bending

Bend to some angle the first shoots at lower stem of rose plants to serve as reserve (Kitchen) for photosynthesis instead of pruning. It also stimulates shooting. Bending methods can be categorized as;

- ✓ High bending; weak, thin, damaged and blind shoots are bent at pea bud size or when shoot is mature but before flowering.
- ✓ Low bending; bend is close to graft union point. It is commonly applied with stenting which promotes bud break from the lower points, resulting into longer stems and better flower quality because nutrients from the soil want take long to reach the near shoot.

2.7: Physiological disorders

2.7.1: Blind shoot

This is when a normal flowering shoot fails to develop a flower on the apical end of the stem a phenomenon known as blind shoot. The sepals and the petals are fully expanded but reproductive parts are absent, probably caused by pests and disease infestation, chemical residue, insufficient light and other factors.

2.7.2: Color fading

Off-colors are prevalent within some yellow varieties, the petals may be green or dirty white instead of a clear yellow this is caused by low temperature at night. Use of organic phosphates and some insecticides in some cases cause bluish- color flowers to develop in pink or red varieties.

2.7.3: Limp neck.

Wilt occurs at the peduncle of a flower and this makes the flower bud to become too heavy for the stem to carry. Possible cause is insufficient water absorption which can be solved by cutting off 1 to 2 inches of the lower stem and placing the cut stem in water at 37 ^{0}C.

2.7.4: Bull head

Flower bud appears flat since the centre petals remain partly developed. This is prevalent on bottom breaks as they are faster in growth rate. Its causes are not clear, however lack of carbohydrates is a possibility and insect bites may be another cause.

2.7.5: Bent neck

Studies have shown that Bent Peduncle Phenomenon is a post harvest physiological disorder in cut rose flowers caused by pre-harvest factors like harvesting time, in that flower harvested at mature age less quick than that harvested pre- maturely. Vascular occlusion and lack of lime during growth of rose plants contribute too. However, bent neck also occurs in still rose plants growing in greenhouses that are not yet cut from the mother plants. The gradient of susceptibility to bent neck is variant with cultivars and plant age.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study site

This experiment was conducted in greenhouses of Jambo Roses ltd located at 00°09’54.5”N32°28’07.9”E, Kajjansi Town Council, Wakiso District near lake Victoria. Sitting on a land of more than 30 hectares with about 22.5 hectares cultivated.

Elevation of 100 m (200 ft).

3.2Material.

Materials used were Cultivars of sweet heart and intermediate rose in Greenhouses of Jambo Roses limited.

3.3 Experimental design

Experimental design used was Completely Randomized Design and the factors considered were cultivar, plant age, 5 replicates, and 11treatments.

3.4Data collected

Data was collected after every week (once a Week) for Six weeks on the following parameters:

- Stem length, s
- Flower bud weight
- Bud diameter,
- Internode number
- Neck diameter,

3.5**Data analysis**

- Data was subjected to ANOVA using R and Rstudio-software.
- Significance differences and means were established using LSD test at5% (1%) significance levels.

CHAPTER FOUR: RESULTS

4.1 Fraction of stems without bent neck.

Fraction of stems without bent neck of seven cultivars of rose plants was compared in (fig: 1) and no significant difference existed (*P*=0.335), even no significant difference was observed in the interaction between the cultivar and the age (*P*=0.161). There was also no significant difference in the main effects ofboth factors ofcultivar (fig: 2) and (*P*=0.161) and the neck (fig: 3) with (*P*=0.876).

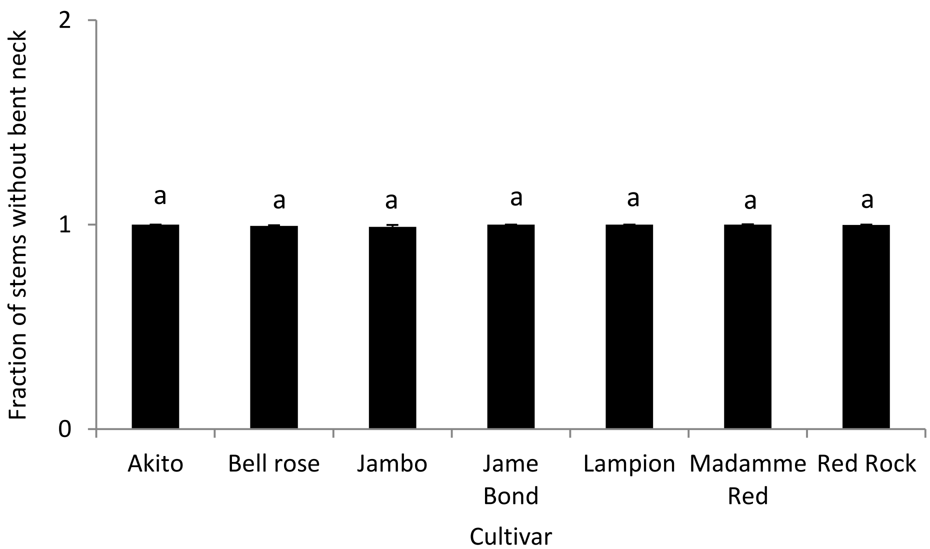

Figure 1: Fraction of stems without bent neck for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

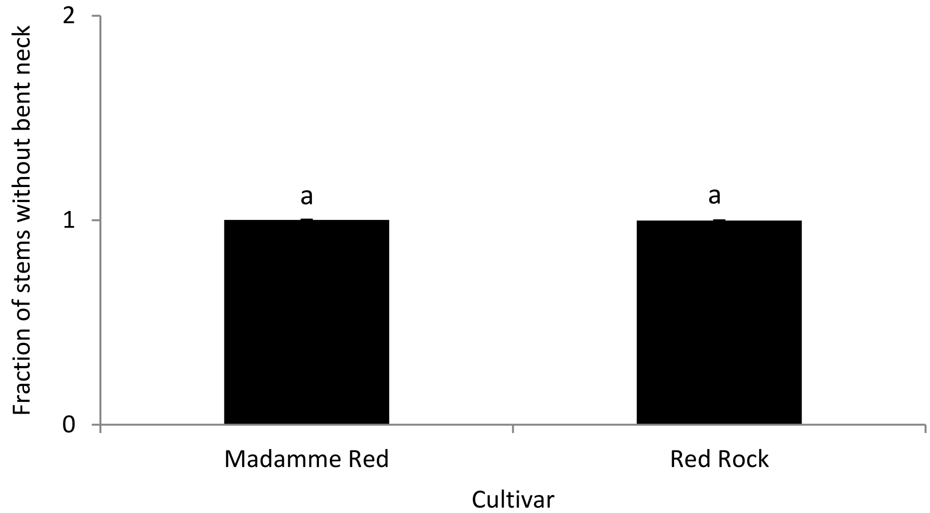

Figure 2: Fraction of stems without bent neck for rose plants of different cultivars of (Mademme Red, n= 180 and Red Rock, n=180). Means followed by different letters differ from each other significantly (P=0.05). Bars represent standard errors of the means.

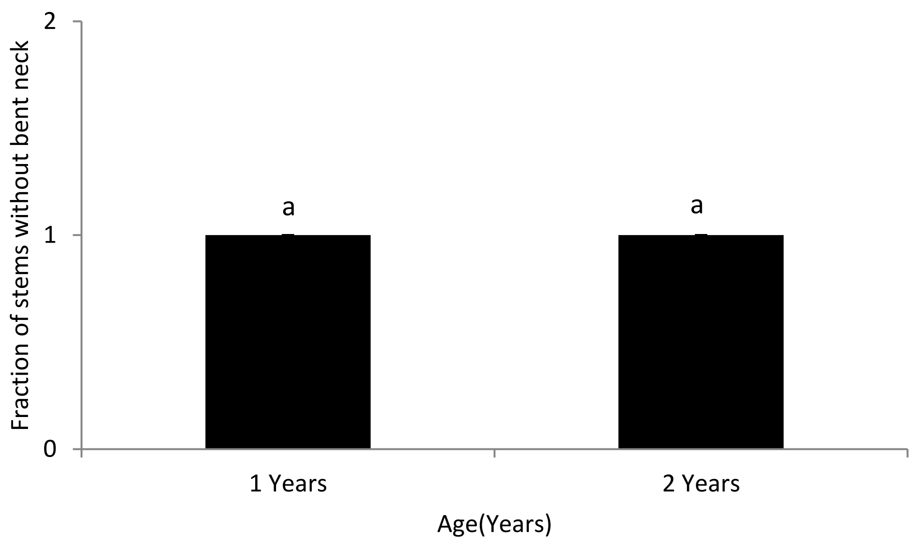

Figure3: Fraction of stems without bent neck of (Mademme Red, n= 180 and Red Rock, n=180). With different ages of, 1 Year and 2Years.Means followed by different letters differ from each other significantly (P=0.05). Bars represent standard errors of the means.

4.2 Fraction of stems with bent neck.

Fraction of stems with bent neck of seven cultivars of rose plants was compared in (fig: 4) and no significant difference existed (*P*=0.137) even no significant difference was observed in the interaction between the cultivar and the age (*P*=0.320).There was also no significant difference in the main effects ofboth factors ofcultivar (fig: 5) and (*P*=0.259) and the neck (fig: 6) with (*P*=0.330).

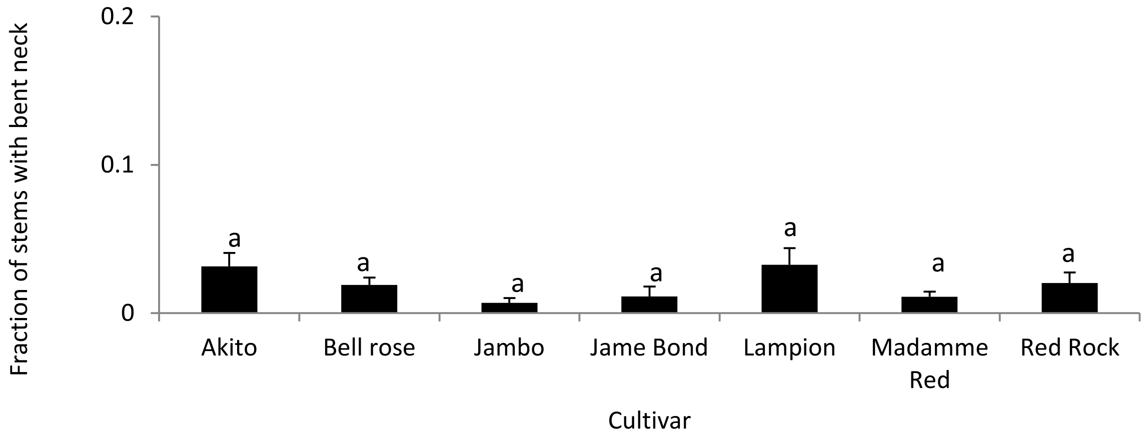

Figure 4: Fraction of stems with bent neck for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

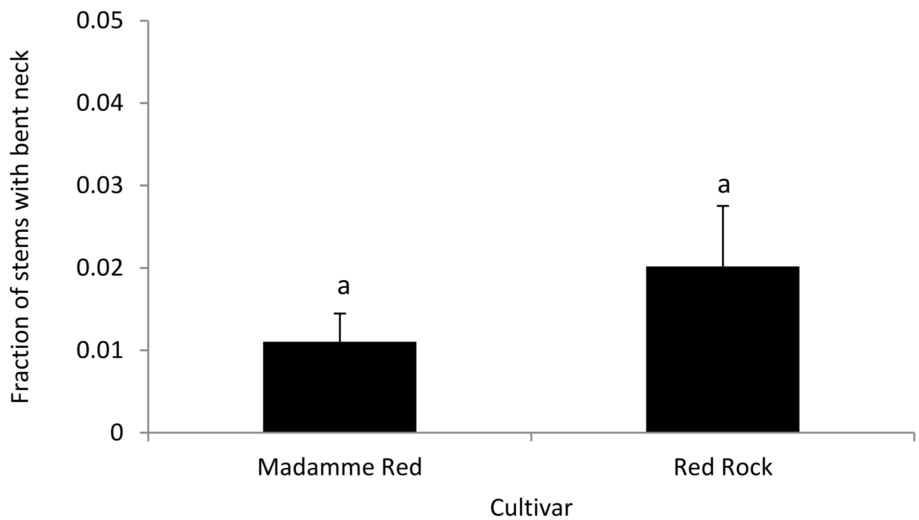

Figure 5: Fraction of stems with bent neck for rose plants of different cultivars of (Mademme Red, n= 180 and Red Rock, n=180). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

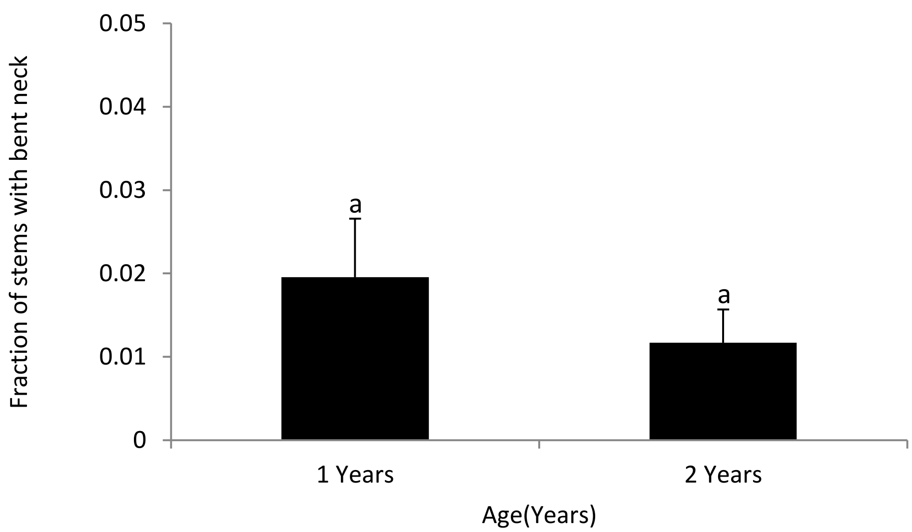

Figure 6: Fraction of stems with bent neck of (Mademme Red, n= 180 and Red Rock, n=180). With different ages of, 1 Year and 2 Years. Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

4.3 Stem length

There was no significant effect of interaction between cultivar and the neck on the stem length (*P*=0.947) as well as the cultivar group (sweetheart and intermediate) and the neck (*P*=0.572). No significant difference was observed in the main effect of the cultivar (fig: 7) with(*P*=0.078) and a significance difference existed with neck as a factor (figure 8)with(*P*=0.0004).No significant difference was observedin the main effect of the cultivar group (figure 9) with (*P*=0.737)and a significance difference existed with neck as a factor (figure 10)with(*P*=0.0003).

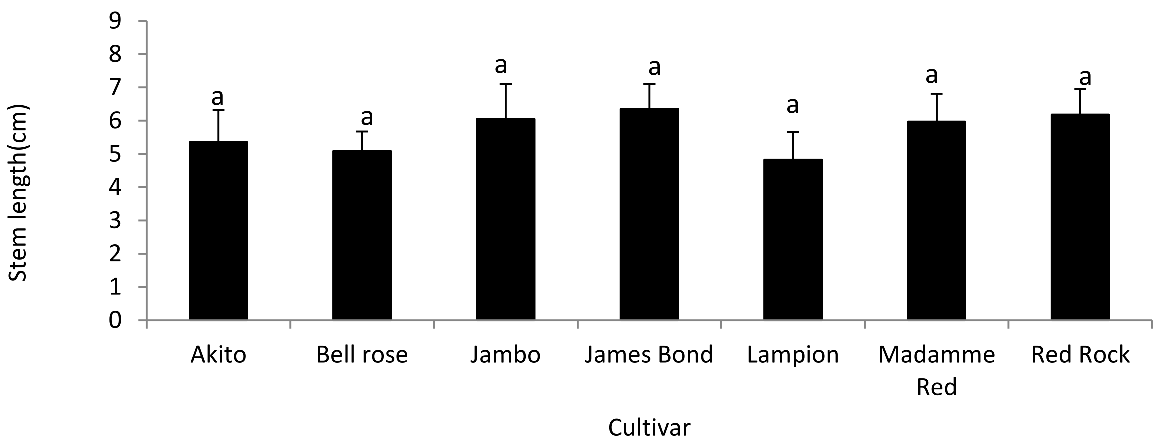

Figure 7: stems length for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

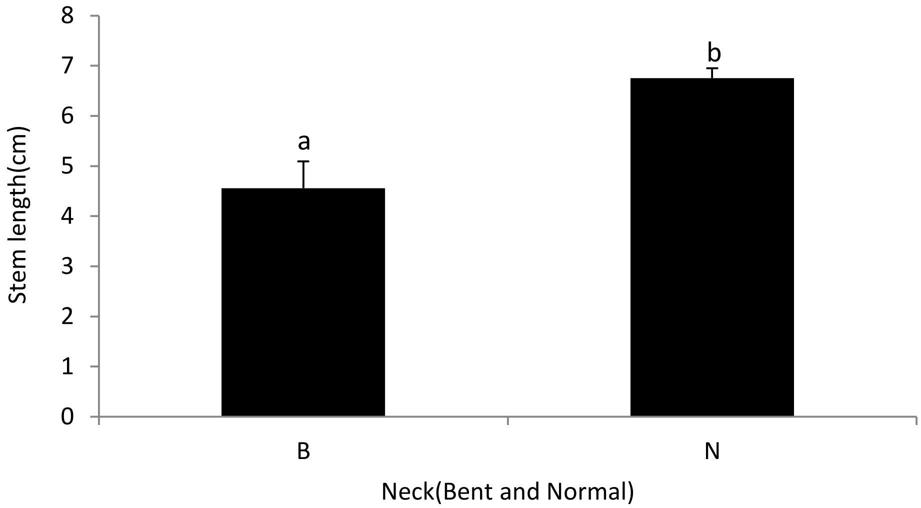

Figure 8: Stem length of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

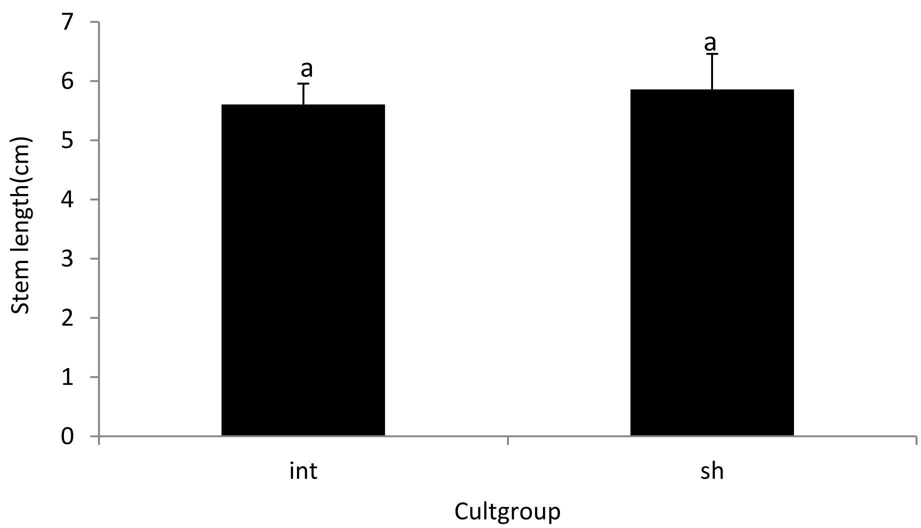

Figure 9: stems length for rose plants of different cultivar groups of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

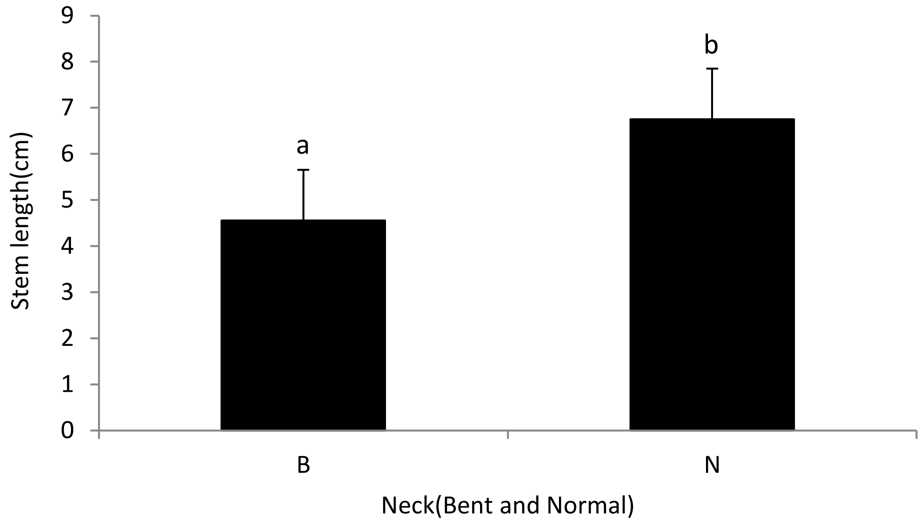

Figure 10: Stem length of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

4.4 Bud weight

There was no significant effect of interaction between cultivar and the neck on the bud weight (P=0.617).as well as the cultivar group (sweetheart and intermediate) and the neck (P=0.894).No significant difference was observed in the main effect of the cultivar (fig:11) with(*P*=0.778) and no significance difference existed with neck as a factor (fig:12)with(*P*=0.989).No significant difference was observedinthe main effect of the cultivar group (fig:13) with(*P*=0.778) and no significance difference existed with neck as a factor (fig:14)with(*P*=0.989).

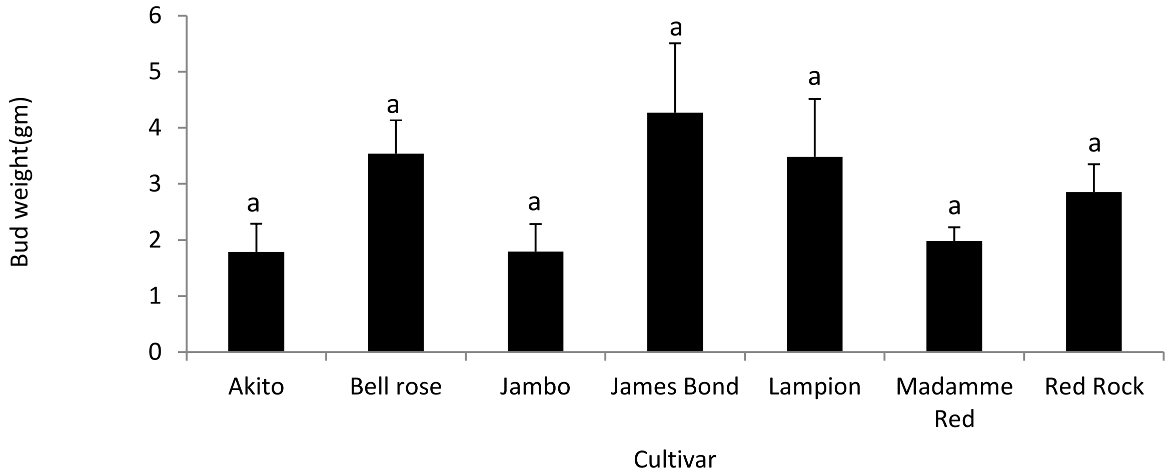

Figure 11: Bud weight for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

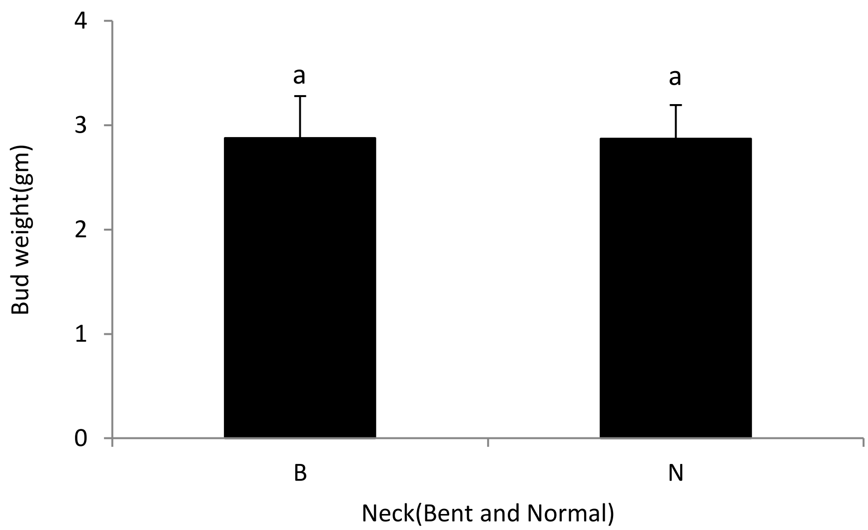

Figure 12:Bud weight of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

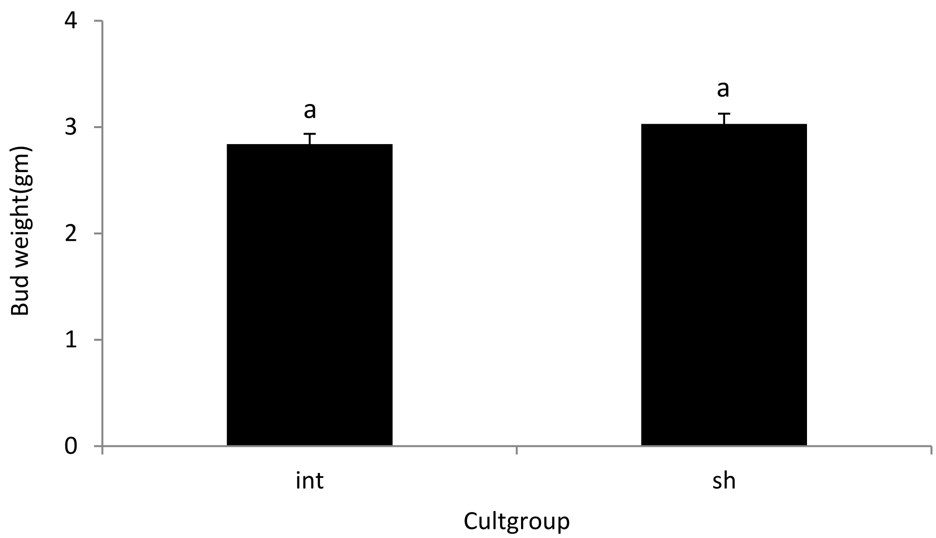

Figure 13: Bud weight for rose plants of different cultivar group of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

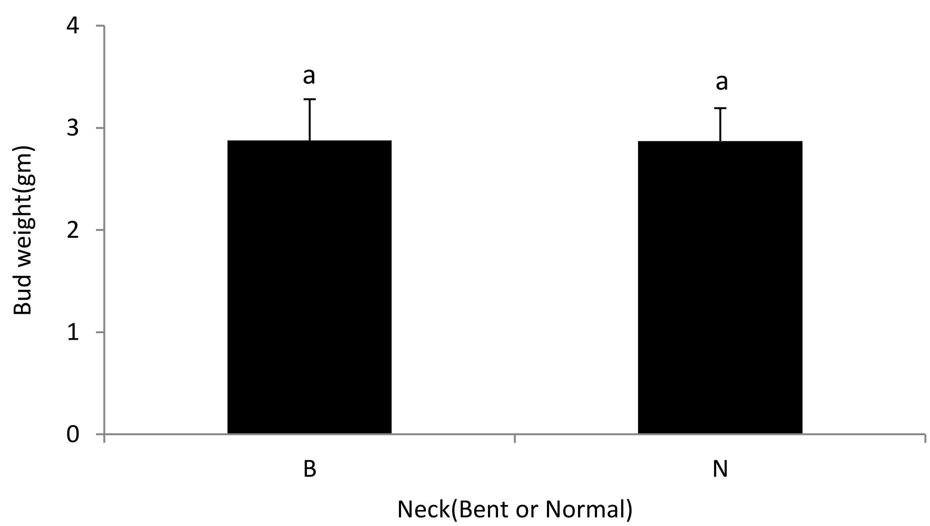

Figure 14: Bud weight of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

4.5 Internode number.

There was no significant effect of interaction between cultivar and the neck on the Internode number (*P*=0.05914).as well as the cultivar group (sweetheart and intermediate) and the neck (*P*=0.5612).No significant difference was observed in the main effect of the cultivar (fig: 15) with (*P*=0.28895) and a significance difference existed with neck as a factor (fig:16)with(*P*=0.0092).

No significant difference was observedinthe main effect of the cultivar group (fig:17) with(*P*=0.0784) and asignificance difference existed with neck as a factor (fig:18)with(*P*=0.0113).

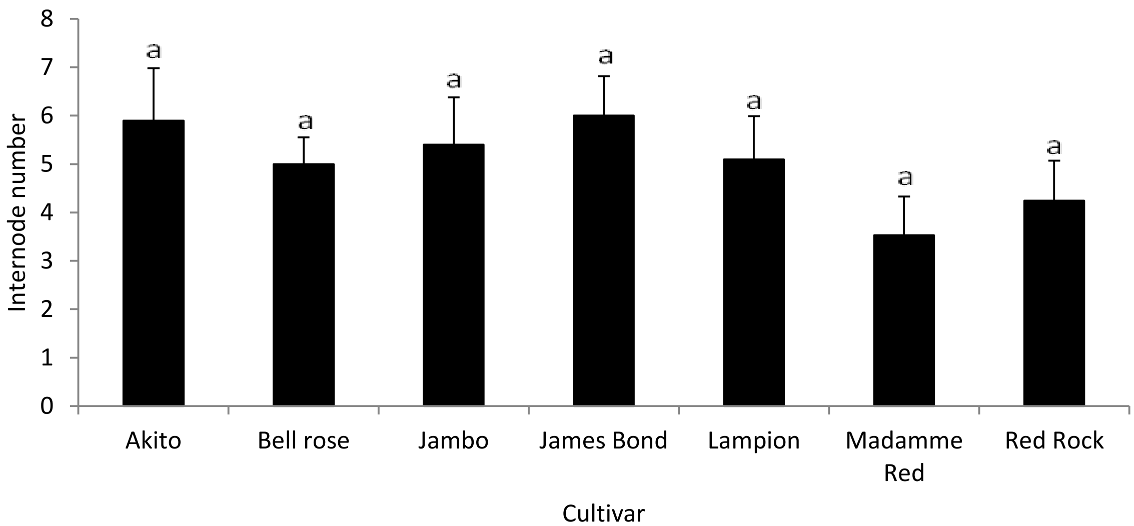

Figure 15: Internode number for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

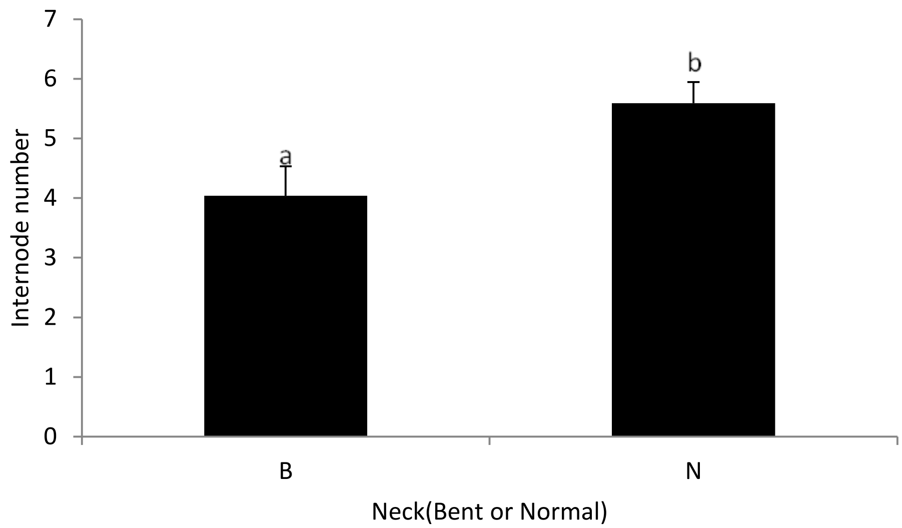

Figure 16: Internode number of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

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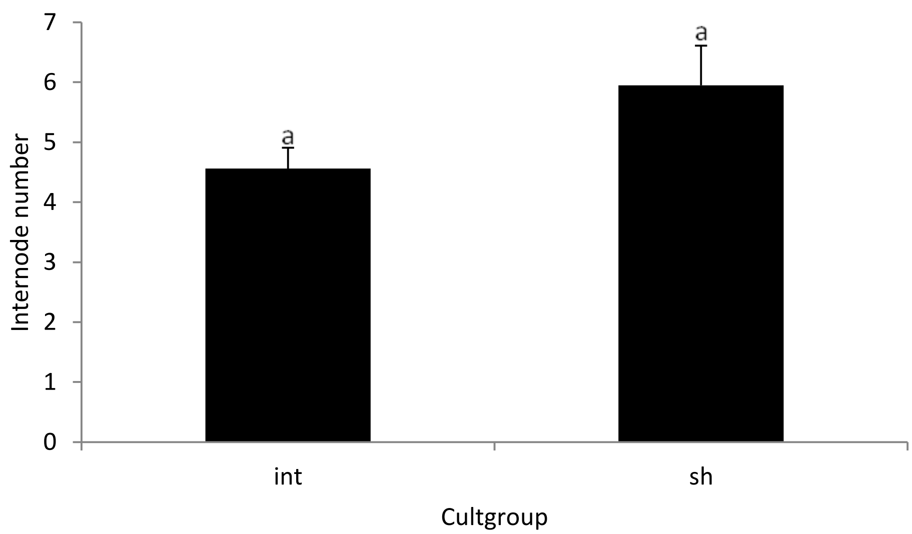

Figure 17: Internode number for rose plants of different cultivar group of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

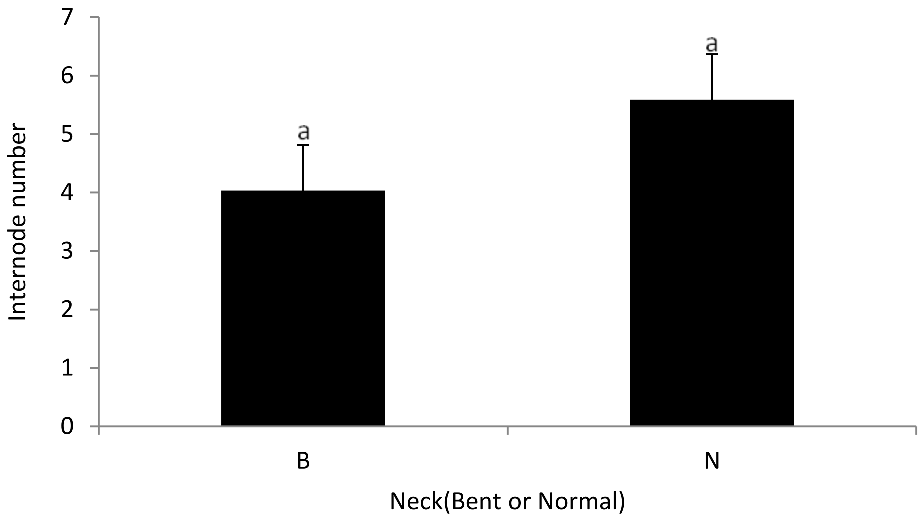

Figure 18: Internode number of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

4.6 Neck diameter.

There was no significant effect of interaction between cultivar and the neck on the stem neck diameter (*P*=0.515).as well as the cultivar group (sweetheart and intermediate) and the neck (*P*=0.9371). A significant difference was observed in the main effect of the cultivar (fig: 19) with (*P*=0.042and no significance difference existed with neck as a factor (fig: 20) With (*P*=0.742).No significant difference was observed in the main effect of the cultivar group (fig: 21) with (*P*=0.0188) and no significance difference existed with neck as a factor (fig: 22) With (*P*=0.6297).

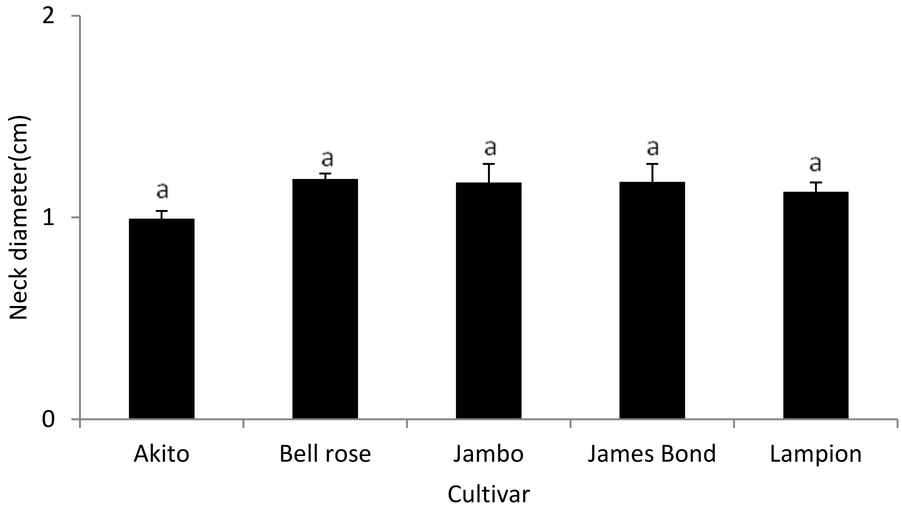

Figure 19: Neck diameter for rose plants of different cultivar of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

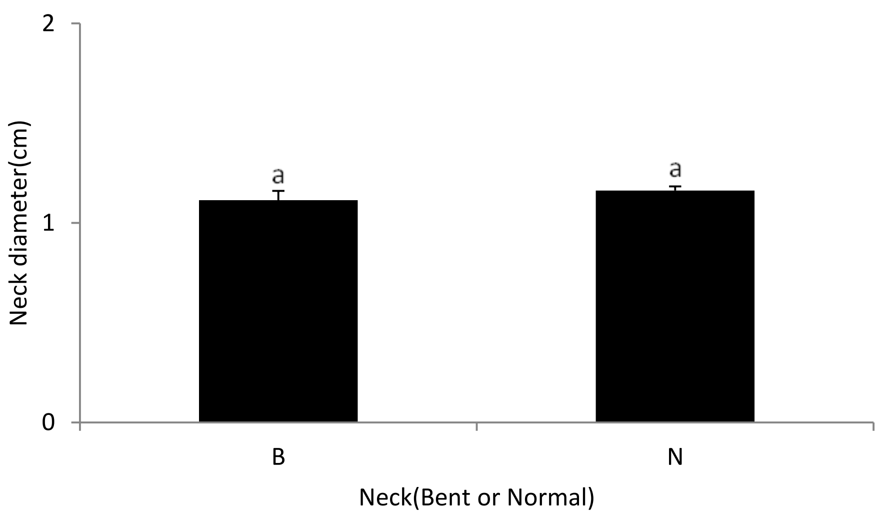

Figure 20: Neck diameter of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

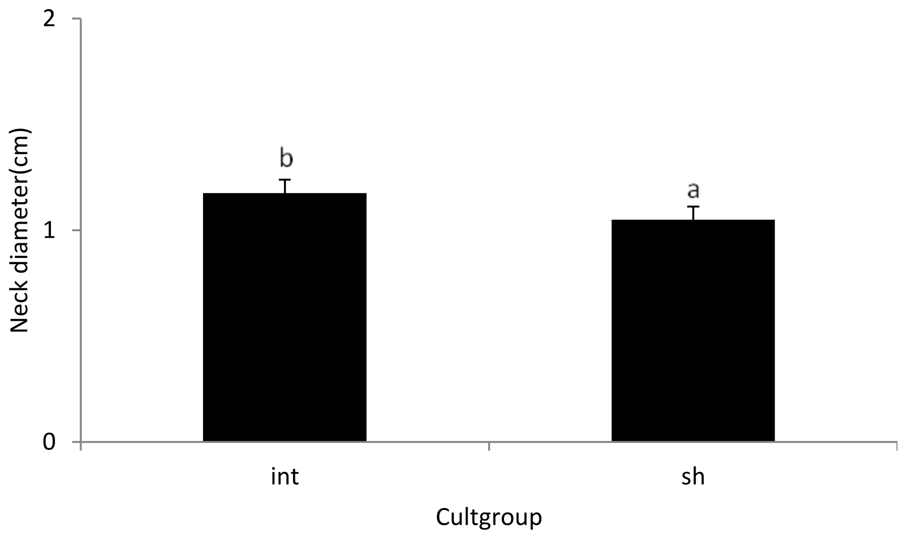

Figure 21: Neck diameter for rose plants of different cultivar groups of Sweat heart (Akito, n= 90, James Bond, n=90) and Intermediate (Bell rose, n= 270, Jambo, n= 90, Lampion, n= 90, Madamme Red, n=180, Red Rock, n=180). Means followed by different letters differ from each other significantly (*P=0.05*). Bars represent standard errors of the means.

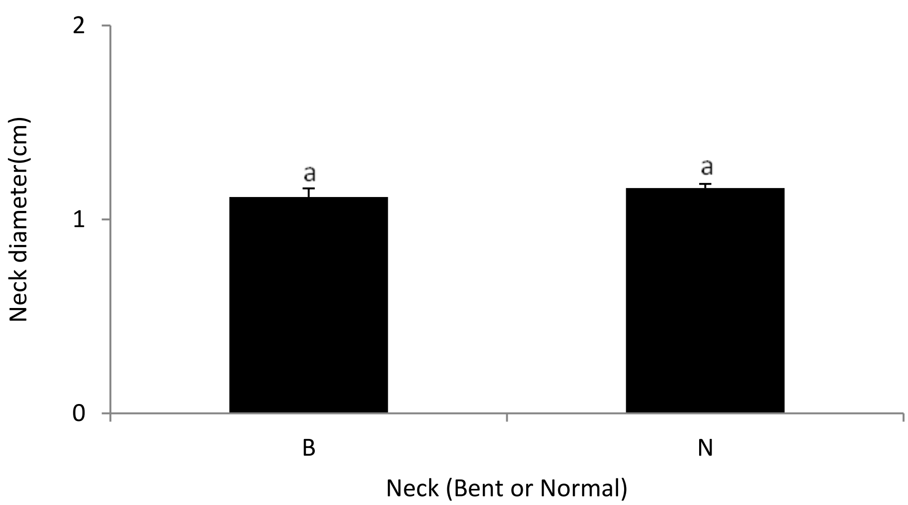

Figure 22: Neck diameter of different rose plants where compared based on neck with two levels of (bent neck, normal neck). Means followed by different letters differ from each other significantly (*P*=0.05). Bars represent standard errors of the means.

Table 1:
Summary of results for parameters evaluated against cultivars

	Akito	**Bell rose**	**Jambo**	**James Bond**	**Lampion**	**Madamme Red**	**Red Rock**	**P value**
Fraction Normal	0.97±0.00	0.99±0.003	0.99±0.01	0.98±0.00	0.97±0.00	0.99±0.001	0.99±0.001	0.161
Fraction bent neck	0.03±0.001	0.01±0.005	0.01±0.003	0.02±0.007	0.03±0.011	0.01±0.003	0.01±0.007	0.137
Stem length (cm)	0.03±0.96	5.09±0.59	6.05±1.06	6.36±0.738	4.83±0.825	5.98±0.837	6.19±0.765	0.947
Bud weight (g)	0.03±0.50	3.53±0.602	1.79±0.488	4.27±1.236	3.48±1.036	1.98±0.247	2.86±0.494	0.894
Internode number	0.03±1.08	5±0.553	5.4±0.980	6±0.817	5.1±0.888	3.53±0.799	4.24±0.826	0.059
Neck diameter (cm)	0.03±0.04b	1.19± 0.03 a	1.17± 0.093 ab	1.18±0.090 ab	1.13±0.046 ab			0.018

Table 2: Summary of results for comparison of parameters in bent neck and normal neck

	Bent neck	**Normal**	**P value**
Stem length (cm)	4.6±00.541 a	6.8±0.197 b	0.000252
Bud weight (g)	2.9±0.401	2.9±0.322	0.617
Internode number	4.03±0.494	5.59±0.353	0.5612
Neck diameter (cm)	1.11±0.045 a	1.16±0.022 b	0.042

Table 3: Summary of results comparing cultivar group (intermediate and sweet heart)

	Intermediates	**Sweet hearts**	**P value**
Stem length (cm)	5.61±0.350	5.86±0.500	0.572
Bud weight (g)	2.84±0.272	3.03±0.709	0.778
Internode number	4.56±0.347	5.95±0.659	0.289
Neck diameter (cm)	1.18±0.022	1.05±0.039	0.63

CHAPTER FIVE: DISCUSSION OF RESULTS

The objectives of this study were to determine the relationship between 1) flower bud sizes and stem size in rose stems with bent necks, 2) bent neck formation and the size of vascular tissues, and 3) bent neck formation and the number and volume of cells around the neck region of the stem. In addition, 1) the impact of the presence of bent necks on flower quality (stem length, stem diameter, bud diameter) and 2) the occurrence of bent necks in roses of different varieties and age groups was determined.

Findings from this study showedthat fraction of stems without bent neck exhibited similar values in all the cultivars the same scenario was reflected in the fraction of stems with bent neck but with much higher values in the fraction of stems without bent neck. Stem length in bent necks were shorter than those in normal necks in rose cultivars subjected to this research but not much different in the comparison of individual plants other than Akito which had the smallest length while the cultivar groups had similar stem length.

Neck diameter of the bent was found to be smaller than in the normal neck and much smaller in the sweetheart relative to the intermediate. These results were in resemblance to that of the previous research reported by Joanita, on the variety of sweetheart.Bent neck distorts the vascular tissue of the plant and hence affecting the physiological processes like distribution and photosynthesis of photo assimilates this paralyses normal growth and development in the plants
I observed in the field that bent neck was common due to displacement of one of the sepals into the flower stem lower than the normal position of the other sepals and a very sharp curvature is always noted in that bent neck.

5.1 Fraction of stems without bent neck

Fraction of stems without bent neck showed no significant difference in response to the factors of cultivar and age. The fraction of stems without bent neck presented in average the same value across the rose cultivars of Akito, Bell Rose, Jambo, James Bond, Lampion, Madamme Red and Red Rock. But much higher than in the fraction of stems with bent neck

.5.2 Fraction of stems with bent neck

Fraction of stems with bent neck no significant difference was observed.The rose cultivars of Akito, Bell Rose, Jambo, James Bond, Lampion, Madamme Red and Red Rock have shown the same values in the fraction of stems with bent neck.

5.3 Stem length

Interaction of factors of interest (cultivar, neck) had (*P*=0.947235) and (cultivar group, neck) with (*P*=0.572488) implying that no significant differences were observed.Main effect of the neck exhibited significant difference in stem length (*P*=0.000252) while other factors like the cultivar, cultivar group and age presented no significant effect with the probabilityvalues greater than 0.05. The stem length of bent neck flowers were confirmed to be shorter than it was in the normal neck rose plants in all the different cultivar and cultivar groups. This occurrence must have been caused by improper photo assimilate distribution in the bent neck that reduces physiological processes of growth and development.

Bent neck probably causes reduction in the number and surface of photosynthetic parts of the plants hence adjusting Source: Sink ratiolowering food production and supply to all the parts of the plant. In consideration of cultivar groups, stem length was not so much different in the sweetheart and the intermediate. While within the group cultivar of sweetheart stem length is found to be taller in James Bond than in Akito. This variation also existed within the cultivars of lampion being with shortest length followed by Bell Rose but Jambo, Madamme Red and Red Rock were averagely not different in length.

5.4Bud weight

Cultivar and neck interaction (*P*=0.894), cultivar group and neck interaction (P=0.617) also proved no significant differences.

Main effects of all the above factors presented no significant differences as their probability values were above (*P*=0.05). Bud weight was observed to be lower in Akito than in James Bond among the sweetheart. Jambo and Madamme Red were the lowest weighing in the intermediate followed by Red Rock, Lampion, and Bell Rose respectively.Bud weight had no variation when it came to the comparison of the cultivar groups of the sweetheart and the intermediate and even the bent neck and the normal neck.

5.5Internode number

No significant differences were observed with factor interactions, however the main effect of neck exhibited significant effects with (*P*=0.0092) when considered cultivar and neck. (*P*=00113) as cultivar group and neck were considered.Internode number was observed to be less in Akito as a Sweetheart cultivar relative to James Bond a sweetheart. In within the intermediate, Madamme Red and Red Rock were no different and the least in Internode number as compared to Bell Rose, Jambo and Lampion.

In general, Akito had the least number of Internodefollowed by Madamme Red and Red Rockbut James Bond with the highest.Internode number was also observed to be fewer in the bent neck than in the normal neck flower. Probably caused by reduced food production in the bent neck since they have lower photosynthetic ability in food production.

5.6Neck diameter

Interaction of cultivar and neck diameter (*P*=0.515), Interaction of cultivar group and neck diameter (*P*=0.9371) no significant effect was denoted.Main effect of cultivar (*P*=0.042) and cultivar group (*P*=0.0188) have expressed significant differences with neck diameter. Showing thinner neck diameters in the bent neck than the normal neck rose flower stems. Neck diameter within the sweetheart showed that Akito had thinner bent neck relative to James Bond. However this scenario was not common within the cultivar group of intermediate ones. This was predicted to be genetically in occurrence.Bent neck in comparison to normal showed that neck diameter was higher in the normal neck than in the bent neck in all the crops subjected to the research project.Mean while between the sweetheart and the intermediate, there existed no difference in the neck diameter.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Fraction of stems without bent neck exhibited similar values in all the cultivars and the same scenario was reflected in the fraction of stems with bent neck but with much higher values in the fraction of stems without bent neck.

Stem length in bent necks were shorter than those in normal necks in rose cultivars subjected to this research but not much different in the comparison of individual plants other than Akito which had the smallest length while the cultivar groups had similar stem length.

In general, Akito had the least number of Internode followed by Madamme Red and Red Rock but James Bond with the highest .Internode number was also observed to be fewer in the bent neck than in the normal neck flower. Probably caused by reduced food production in the bent neck since they have lower photosynthetic ability in food production

Bud weight was observed to be lower in Akito than in James Bond among the sweetheart. Jambo and Madamme Red were the lowest weighing in the intermediate followed by Red Rock, Lampion, and Bell Rose respectively.

Bud weight had no variation when it came to the comparison of the cultivar groups of the sweetheart and the intermediate and even the bent neck and the normal neck

Neck diameter of the bent was found to be smaller than in the normal neck and much smaller in the sweetheart relative to the intermediate. Logically implying that there were smaller cells in number, size, or thickness at the neck region of the bent neck.

6.2 Recommendations

More research should be directed towards finding occurrence of bent neck at cellular level.There is need to vary plant age and provide all the possible conditions at your own setting other than using the available and already established plants.

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APPENDICES

Appendex; 1: RSCRIPT CODES

```
#setting the working Directory
setwd("C:/Users/DRANI/Desktop/2021spDM")
#importing an excel file into R
dm<-read.csv("Vasc11.csv",header=TRUE)
#obtaining a summary of the data file
summary(dm)
#the structure of our data
str(dm)
##changing the column for Cultivar into a factor
dm$Cultivar<-factor(dm$Cultivar)
##changing the column for Age into a factor
dm$Age<-factor(dm$Age)
##changing the column for Cultivar group into a factor.
dm$Cultgroup<-factor(dm$Cultgroup)
str(dm)
#4.1A fraction of stems without bent neck
#running a one way ANOVA
anovaFSNF<-aov(dm$FSNF~dm$Cultivar)
summary(anovaFSNF)
#mean separation
library(agricolae)
FSNFmeanseparation<-HSD.test(anovaFSNF,c("dm$Cultivar"),group=TRUE)
FSNFmeanseparation
#4.2A fraction of stems with bent neck
#running a one way ANOVA
anovaFSBN<-aov(dm$FSBN~dm$Cultivar)
summary(anovaFSBN)
#mean separation
FSBNmeanseparation<-HSD.test(anovaFSBN,c("dm$Cultivar"),group=TRUE)
FSBNmeanseparation
```

```
#running a two way ANOVA
#importing an excel file into R
dm12<-read.csv("Vasc12.csv",header=TRUE)

#4.1 fraction of stems without bent neck
#4.1B Cultivar and Age.
#running a Two way ANOVA
FSNFanova<-aov(dm12$FSNF~dm12$Cultivar*dm12$Age)
summary(FSNFanova)
#Main effect of cultivar
FSNFmeanseparation<-HSD.test(FSNFanova,c("dm12$Cultivar"),group=TRUE)
FSNFmeanseparation
#Main effect of Age
FSNFmeanseparation<-HSD.test(FSNFanova,c("dm12$Age"),group=TRUE)
FSNFmeanseparation

# 4.2 fration of stems with bent neck
#4.2B Cultivar and Age
#running a two way ANOVA
FSBNanova<-aov(dm12$FSBN~dm12$Cultivar*dm12$Age)
summary(FSBNanova)
#Main effect of cultivar
FSBNmeanseparation<-HSD.test(FSBNanova,c("dm12$Cultivar"),group=TRUE)
FSBNmeanseparation
#Main effect of Age
FSBNmeanseparation<-HSD.test(FSBNanova,c("dm12$Age"),group=TRUE)
FSBNmeanseparation

#importing an excel file into R
dm9<-read.csv("Vasc9.csv",header=TRUE)

#4.3 Stem length
#4.3A Cultivar and neck
```

```
SLanova<-aov(dm9$SL~dm9$Cultivar*dm9$neck)
summary(SLanova)
#Main effect of cultivar
SLmeanseparation<-HSD.test(SLanova,c("dm9$Cultivar"),group=TRUE)
SLmeanseparation
#Main effect of neck
SLmeanseparation<-HSD.test(SLanova,c("dm9$neck"),group=TRUE)
SLmeanseparation

#Running a two way ANOVA
#4.3B Cultgroup and neck
SL2anova<-aov(dm9$SL~dm9$Cultgroup*dm9$neck)
summary(SL2anova)
#Main effect of cultgroup
SL2meanseparation<-HSD.test(SL2anova,c("dm9$Cultgroup"),group=TRUE)
SL2meanseparation
#Main effect of neck
SL2meanseparation<-HSD.test(SL2anova,c("dm9$neck"),group=TRUE)
SL2meanseparation

#4.4 Bud weight
#4.4A Cultivar and neck
#running a two way ANOVA
BWanova<-aov(dm9$BW~dm9$Cultivar*dm9$neck)
summary(BWanova)
#Main effect of cultivar
BWmeanseparation<-HSD.test(BWanova,c("dm9$Cultivar"),group=TRUE)
BWmeanseparation
#Main effect of neck
BWmeanseparation<-HSD.test(BWanova,c("dm9$neck"),group=TRUE)
BWmeanseparation

#running a two way ANOVA
#4.4B Cultgroup and neck
```

```
BW2anova<-aov(dm9$BW~dm9$Cultgroup*dm9$neck)
summary(BW2anova)
#Main effect of cultgroup
BW2meanseparation<-HSD.test(BW2anova,c("dm9$Cultgroup"),group=TRUE)
BW2meanseparation
#Main effect of neck
BW2meanseparation<-HSD.test(BW2anova,c("dm9$neck"),group=TRUE)
BW2meanseparation

#4.5 Internode number
#4.5A Cultivar and neck
#running a two way ANOVA
INanova<-aov(dm9$IN~dm9$Cultivar*dm9$neck)
summary(INanova)
#Main effect of cultivar
INmeanseparation<-HSD.test(INanova,c("dm9$Cultivar"),group=TRUE)
INmeanseparation
#Main effect of neck
INmeanseparation<-HSD.test(INanova,c("dm9$neck"),group=TRUE)
INmeanseparation

#running a two way ANOVA
#4.5B Cultgroup and neck
IN2anova<-aov(dm9$IN~dm9$Cultgroup*dm9$neck)
summary(IN2anova)
#Main effect of Cultgroup
IN2meanseparation<-HSD.test(IN2anova,c("dm9$Cultgroup"),group=TRUE)
IN2meanseparation
#Main effect of neck
IN2meanseparation<-HSD.test(IN2anova,c("dm9$neck"),group=TRUE)
IN2meanseparation

#importing an excel file into R
dm10<-read.csv("Vasc10.csv",header=TRUE)
```

```
#4.6 Neck diametr
#4.6A Cultivar and neck
#running a two way ANOVA
NDanova<-aov(dm10$ND~dm10$Cultivar*dm10$neck)
summary(NDanova)
#Main effect of cultivar
NDmeanseparation<-HSD.test(NDanova,c("dm10$Cultivar"),group=TRUE)
NDmeanseparation
#Main effect of neck
NDmeanseparation<-HSD.test(NDanova,c("dm10$neck"),group=TRUE)
NDmeanseparation

#running a two way ANOVA
#4.6B Cultgroup and neck
ND2anova<-aov(dm10$ND~dm10$Cultgroup*dm10$neck)
summary(ND2anova)
#Main effect of cultgroup
ND2meanseparation<-HSD.test(ND2anova,c("dm10$Cultgroup"),group=TRUE)
ND2meanseparation
#Main effect of neck
ND2meanseparation<-HSD.test(ND2anova,c("dm10$neck"),group=TRUE)
ND2meanseparation
```