



## **Incidence of Jelly Seed Disorder in ‘Tommy Atkins’ and ‘Van Dyke’ Mangoes as Affected by Agro-Ecological Conditions in Kenya**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Authors JN and JA designed the study, wrote methodology and wrote the first draft. Authors MH and WO managed the literature search and analysis of the study. All the authors read and approved the final manuscript.*

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### **ABSTRACT**

Jelly seed disorder is one of the major problems in mango production in Kenya as well as other mango producing countries in the world. This problem manifests itself through breakdown of tissues around the seed of the affected fruits resulting in unmarketable fruits. Although the exact cause of jelly seed in mango is unknown, some reports indicate that the condition could be due to imbalance related to Ca, Mg, N and K supply to the fruit. To establish the extent of this problem in Kenya, a study was conducted in 2013 in three major mango producing counties located in different agro-ecological zones namely Embu, Murang'a and Meru. Three farms with homogenous trees of "Tommy Atkins" and "Van Dyke" mangoes were randomly selected per county. Soil and mango leaf analysis were carried out to determine the nutrient status. Rainfall and temperature data were also recorded during the study period. At harvest time, 50 tree-ripe fruits of each variety were randomly sampled from 25 trees per site and sliced along the endocarp to expose the seed then visually examined and scored for the incidence of jelly seed using Galan Sauco scale. Soil analysis showed

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that, Meru vertisol and lithosols soils had higher Ca, Mg, K content compared to Murang'a eutric Nitisol soils and Embu ferralic arenosal soils. Similarly, mango leaves and fruits sampled from Meru county had higher Ca, Mg and K contents than those from Murang'a and Embu. Fruits (both varieties) from Embu county showed higher incidents of jelly seed than those from Murang'a and Meru county. Significantly higher jelly seed incidents were reported in 'Van Dyke' compared to 'Tommy Atkins' mangoes. It can therefore be concluded that incidences of jelly seed depend on the variety as well as agro-ecological zone where the mangoes are produced.

*Keywords: Variety; tissue analysis; mineral content; physiological disorder.*

## 1. INTRODUCTION

Mango is one of the most important and popular fruit crops in Kenya as well as many other parts of the world especially southeast Asia [1,2]. Its popularity is mainly due to its suitability in different agro-ecological zones (AEZs) ranging from sub-humid to semi-arid climates, availability of improved varieties and its richness with vitamins and minerals [3,4]. Eastern and Central regions of Kenya are leading producers of mango with over 38% of the total country production [5,6]. The most important commercial varieties in these regions are Tommy Atkins and Van Dyke. However, many farmers are not able to access prime markets mainly due to quality issues [7,2]. One of the major challenges in production is a physiological disorder known as jelly seed which manifests itself through breakdown of tissues around the seed thus lowering the marketability of the affected fruits [8]. The losses due to this problem are estimated to be as high as 30% [9]. The exact cause of this problem is unknown although it is reported to be brought about by imbalance related to Ca, Mg, K and N supply to the fruit. This imbalance may lead to low Ca:N or low Ca:K ratio thus predisposing the fruits to the disorder [10]. Calcium deficit in the fruit can be caused by either insufficient absorption or competition between growth points of the plant and fruits for available Ca [11].

The beneficial effect of Ca in the fruit is attributed to its ability to enhance the integrity of the cell wall thus increasing fruit tissues consistency during maturation [12]. It is reported that, Ca moves with the transpiration stream and binds with polysaccharides to strengthen cell walls thus preventing cell wall degradation, "leaky" membranes and premature senescence thus resulting in firm fruits with good shelf life [13]. The importance of Ca has been demonstrated in other fruits such as water melon and apple. In watermelon, deficiency of Ca causes blossom

end rot (BED) while in apple it causes bitter pit [13].

The problem of Jelly seed disorder may also be related to inherent factors which make some varieties to show higher levels of susceptibility than others [11]. On this aspect "Van Dyke" is reported to be highly susceptible while 'Edward', 'Irwin' Tommy Atkins and 'Heidi' are reported to be tolerant [11]. Similarly, a preliminary study conducted in Embu showed that "Van Dyke" is a highly sensitive variety while "Tommy Atkins" is moderately sensitive [2]. Another factor which have been reported to influence jelly seed occurrence is the amount of moisture available. According to [11], humid conditions promote the expression of jelly seed. Consequently, given that mangoes in Kenya and other countries are grown over a wide range of agro-ecological zones, it would be necessary to establish whether these conditions variably predispose mango fruits to jelly seed incidence as a first step in developing strategic interventions to managing this disorder. The objective of this study was therefore to determine the incidence of jelly seed physiological disorder in "Tommy Atkins" and "Van Dyke" varieties produced in different agro-ecological zones in Kenya.

## 2. MATERIALS AND METHODS

### 2.1 Location of the Study

This study was carried out in three major mango production counties in Kenya namely Embu, Murang'a and Meru in 2013. In Embu county, the study site was at coordinates 00°32'S 37°41'E and an elevation of 1174 m above sea level (a.s.l). This area is classified as lower midland 3 (LM 3) with loamy sand to clay ferralic arenosal type of soil and has an average annual rainfall of 1206 mm/annum while the average annual temperature is 22.7°C. Murang'a county site was at coordinates 00°46'S 037°E and an elevation of 1340 m a.s.l. This area is classified as upper midlands 4 (UM 4) with extremely deep well

drained, dark reddish brown eutric Nitisol type of soil. The average annual rainfall for this area is 1175 mm/annum while the average temperature is 19.7°C. Meru county site on the other hand was at coordinate 00°03'N 37°39'E and an elevation of 971 m a.s.l. This area is classified as lower midland 4 (LM 4) with moderately well drained dark greyish, cracking clay vertisol and dark brown lithosols type of soil and has an average annual rainfall of 920 mm/annum and average annual temperature of 22.9°C [14].

## 2.2 Sampling

Fifty trees of "Tommy Atkins" and "Van Dyke" of homogenous stand and age were randomly selected from three farms per county (each farm acted as a replicate thus there were three replicates per county). These two varieties are reported to have different levels of susceptibility to jelly seed disorder [11].

## 2.3 Soil and Leaf Sampling

Soil and leaf samples were collected to determine the nutrient status of these farms. Soil samples were obtained at 0-20 cm (top soil) and 50-70 cm depth (sub-soils) while leaf samples were obtained from leaves six to eight month old - leaves of this age are physiologically active, having completely expanded and their nutrient concentration are near their highest and are subsequently more stable [15,16]. Soil and leaf samples were analyzed at National Agricultural Research laboratories in Nairobi as follows:

### 2.3.1 Analysis of soil K, Ca, Mg

Mehlich Double Acid method was used. The soil was oven - dried at 40°C. A samples (< 2 mm) was extracted in a 1:5 ratio (w/v) with a mixture of 0.1 N HCl and 0.025 N H<sub>2</sub>SO<sub>4</sub>. Elements were then determined with a flame photometer.

### 2.3.2 Analysis of total nitrogen

Kjeldahl method was used. The soil was first oven dried at 40°C. A samples (< 0.5 mm) was digested at approximately 350°C with concentrated sulphuric acid containing potassium sulphate, selenium and copper sulphate hydrated. Total N was then determined by distillation followed by titration with diluted standardized 0.007144N H<sub>2</sub>SO<sub>4</sub>.

### 2.3.3 Tissue analysis for K, Ca, Mg

These minerals were first extracted through digestion in tubes with H<sub>2</sub>SO<sub>4</sub> - salicylic acid -

H<sub>2</sub>O<sub>2</sub> and selenium. This method is particularly suited for large series of plant material samples and automated determinations. Potassium was then determined with a flame photometer while Ca, and Mg were determined using atomic absorption spectrophotometer (AAS).

## 2.4 Analysis for Minerals and Incidences of Jelly Seed Disorder

When fruit were at tree-ripe stage which is referred to as stage 5 [3,17] a random sample of 10 fruits per site were analysed for Ca, Mg and K content. In addition, another random sample of 50 fruits of each of the two varieties (sampling was done using guidelines provided for by [18]) was used for the determination of jelly seed incidences as follows; fruits were halved (slicing flush along the endocarp) to expose the seed and examined visually for the incidence of jelly seed disorder. Rating was done using the following scale [19].

- 0= without symptoms
- 1=slightly decomposition of the petiole base without affecting the flesh
- 2=slightly affected flesh near the seed
- 3= 1/3 of the flesh affected
- 4= 2/3 of the flesh affected
- 5= Almost all fruit decomposed

## 2.5 Peel and Flesh Firmness Determination

Another random sample of nine fruits per variety with no incidents of jelly seed was used to determine peel and flesh firmness at the tree-ripe stage per county. Peel firmness was measured at three different spots of the fruits while flesh firmness was determined by slicing the upper portion of the fruit then measuring three different spots using a penetrometer (Model CR-100D, Sun Scientific Co. Ltd, Japan) fitted with a 5 mm probe. The probe was allowed to penetrate the peel and flesh to a depth of 10 mm and the corresponding force required to penetrate this depth determined. Firmness was then expressed as Newton (N) [20]

## 2.6 Data Analysis

Data collected was subjected to ANOVA using GLM procedure of SAS version 8 programme and means were separated using the Student-Newmann-Keul (SNK) test at 5 % level of significance.

### 3. RESULTS AND DISCUSSION

#### 3.1 Soil Nutrient Status and Rainfall in Embu, Meru and Murang'a Counties

Soil analysis of the three Counties indicated that their nutrient status were different with Embu soils having higher significantly ( $P \leq 0.05$ ) Nitrogen level (0.35%) compared to Murang'a (0.11%) and Meru (0.12%). In addition, Meru soils had higher Ca and Mg content than those of Murang'a and Embu counties and slightly higher K content (Fig. 1). These results are similar to what have been reported previously that Murang'a, eutric Nitisol soils and Embu ferralic arenosal soils are generally low in Ca and therefore Ca:K ratio is low [21] and perhaps this explains the higher incidence of the jelly seed disorder in Murang'a and Embu counties as compared to Meru county. According to [8], jelly seed disorder is generally brought about by imbalance related to low Ca supply to the fruit and it is exacerbated by high N and K levels in the soil. It is reported that high levels of N and K in the soil affect the uptake of Ca by the plant subsequently leading to inadequate levels of Ca in the fruit and as a result, jelly seed disorder may occur [8,12]. According to [8] mango grown on land that encloses former livestock corrals, the incidence of internal breakdown is

significantly higher indicating that a nutrition imbalance is indeed involved.

The higher level of jelly seed disorder in Embu county as compared to Murang'a and Meru counties can also be attributed to higher average annual rainfall of 1206 mm/annum received in Embu compared to 1175 mm/annum and 1078 mm/annum for Murang'a and Meru county respectively. According to [11], environmental factors, such as a moist microclimate, are conducive to the expression of this disorder.

#### 3.2 Mango Leaf Mineral Content in Embu, Meru and Murang'a Counties

The results of mango Leaf analysis for Ca, Mg and K for "Van Dyke" and "Tommy Atkins" grown in Embu, Murang'a and Meru counties are shown in Fig. 2, Fig. 3 and Fig. 4 respectively. Mango grown in Murang'a and Embu generally had lower leaf Ca, Mg and K content than those grown in Meru county. These leaf nutrient levels correlated positively with the soil nutrient levels in the three counties. The significance of these findings is that leaf mineral content is important in determining what ultimately reaches the fruits given that leaf is a highly sensitive integrator of nutrient availability in the soil [22]. In this study it was found that, the mean leaf Ca

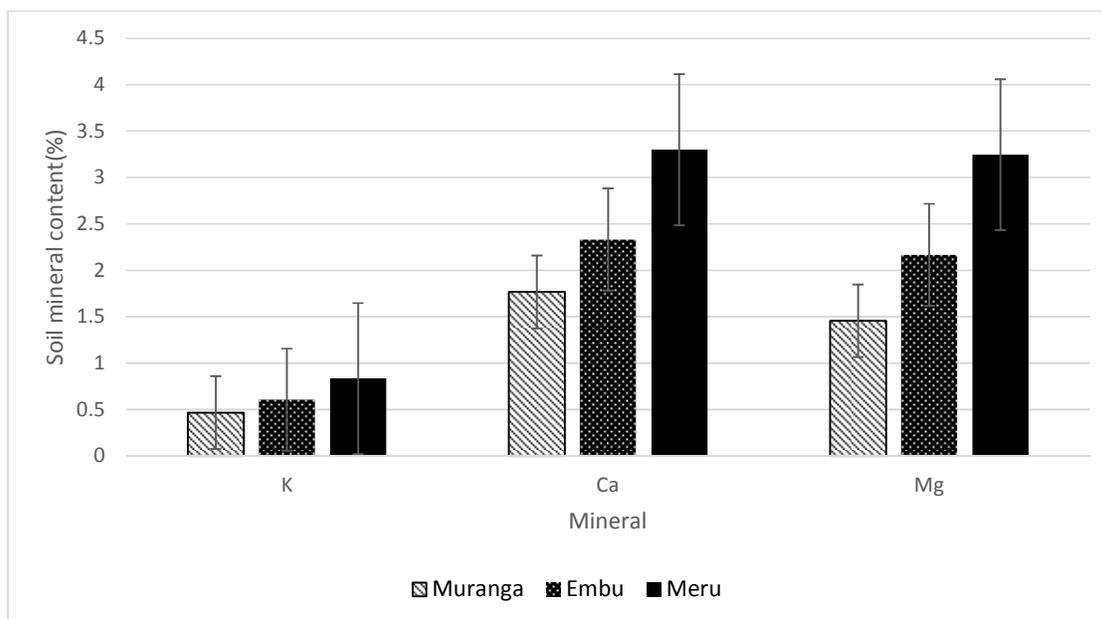
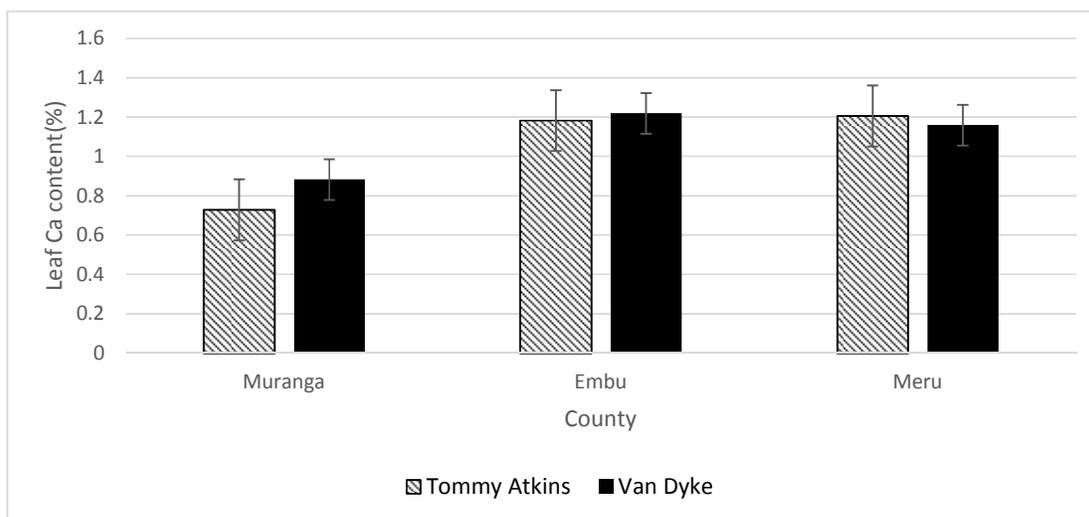
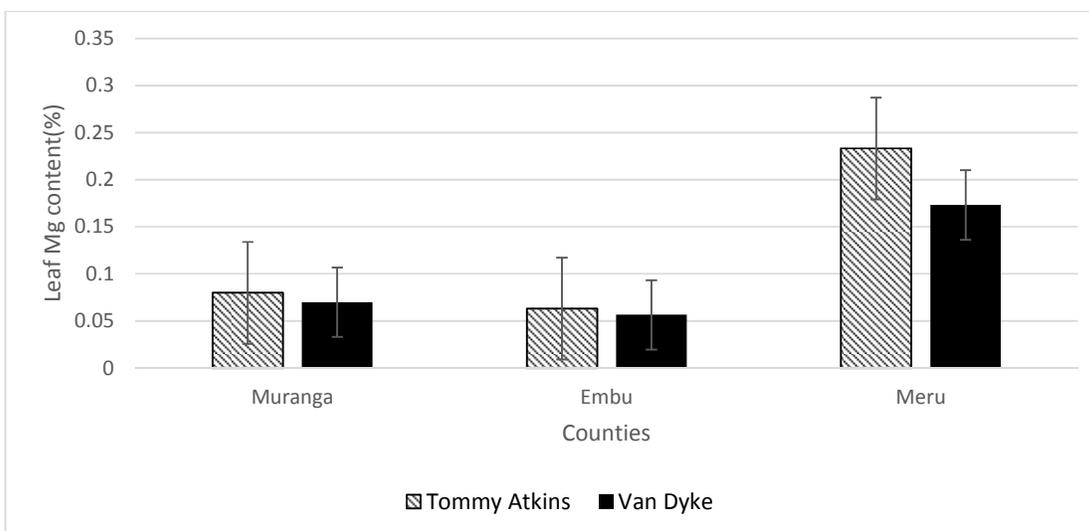


Fig. 1. Soil content of K, Ca and Mg in Murang'a, Embu and Meru counties (n=3;  $\pm$  = standard errors)



**Fig. 2. Leaf content of Ca for “Tommy Atkins” and “Van Dyke” mangoes in Murang’a, Embu and Meru counties (n=3;  $\bar{x}$  = standard errors)**



**Fig. 3. Leaf content of Mg for “Tommy Atkins” and “Van Dyke” mangoes in Murang’a, Embu and Meru counties (n=3;  $\bar{x}$  = standard error)**

and Mg content in all the counties was significantly ( $P \leq 0.05$ ) lower than the standard (2.59% and 0.32% respectively) while K content was significantly ( $P \leq 0.05$ ) higher than the standard (0.544%) in all the counties. This may therefore explain why jelly seed disorder was observed in all the three counties.

### 3.3 Fruit Mineral Content in Different Agro-Ecological Zone

The fruit Ca, Mg and K content of “Tommy Atkins” and “Van Dyke” are shown in Fig. 5, Fig. 6 and

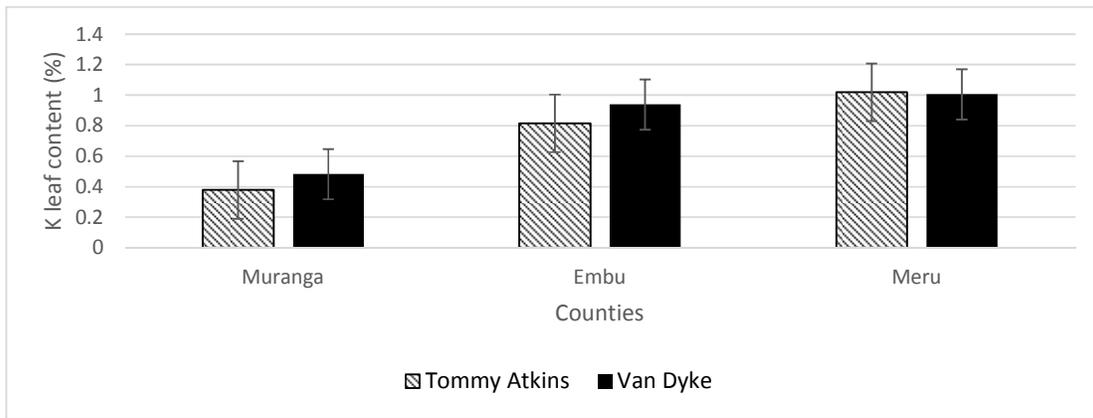
Fig. 7. Fruits from Meru county had higher Ca and Mg content and almost equal amount of K with those from Murang’a and Embu counties. This trend is similar to one found for soil and leaf mineral content in those counties. According to [23], leaf and soil analysis are both important in determining the nutrient requirement of a mango plant for better yield and good fruit quality. It is also reported that high levels of Ca and Mg as well as low ratio of K:Ca in the fruit flesh or coat are enough to prevent physiological disorder [12]. This perhaps explain the relatively low incidence

of jelly seed in Meru county as compared to Murang'a and Embu counties.

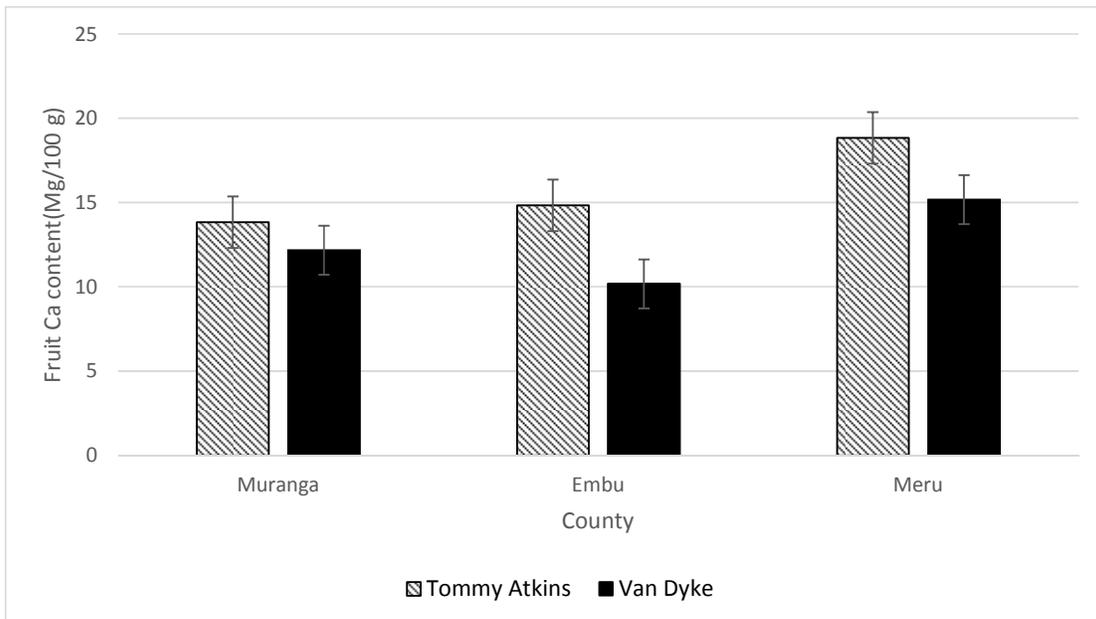
### 3.4 Incidence of Jelly Seed in “Van Dyke” and “Tommy Atkins”

The degrees of jelly seed disorder in “Van Dyke” and “Tommy Atkins” are shown in Table 1. “Van Dyke” had significantly higher incidence of jelly seed disorder than Tommy Atkins in Embu and Murang'a counties but not in Meru county. This can be attributed to genetic variation of these two varieties. The analysis of the two varieties for

peel and flesh firmness at tree-ripe stage showed that, “Van Dyke” has relatively softer peel and flesh than “Tommy Atkins” (Fig. 8). This perhaps makes “Van Dyke” to be more predisposed to this problem than “Tommy Atkins”. This finding concurs with what has been reported by [11], that symptoms of jelly seed disorder are often associated with varietal susceptibility with some varieties being Jelly seed tolerant while others are sensitive based on their inherent characteristics. According to these authors “Van Dyke”, “Osteen” and “Kent” are highly sensitive while ‘Tommy Atkins’, ‘Edward’ and ‘Irwin’ are



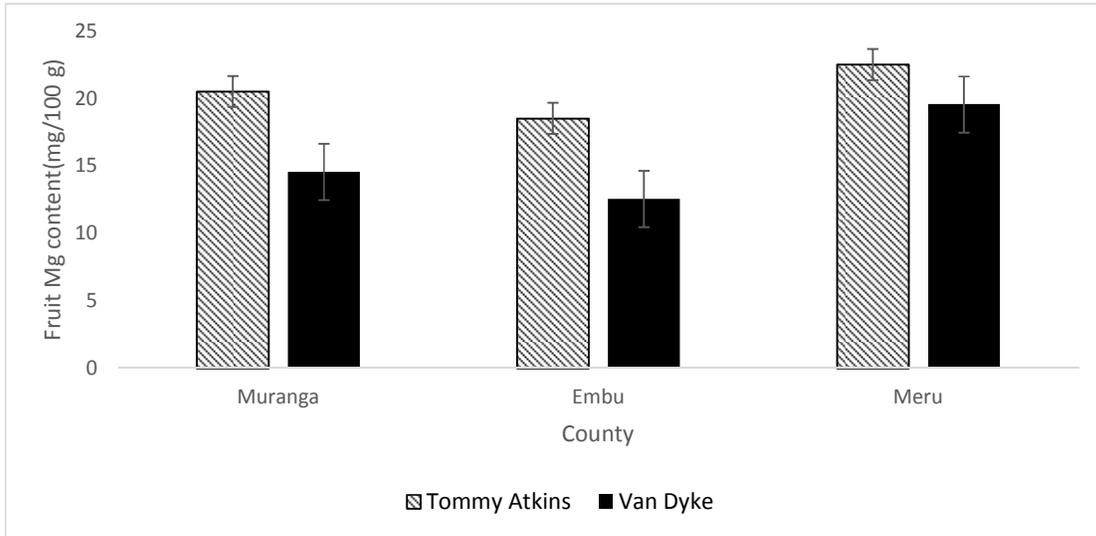
**Fig. 4. Leaf content of K for “Tommy Atkins” and “Van Dyke” mangoes harvested from Murang’a, Embu and Meru counties (n=3;  $\pm$  = standard errors)**



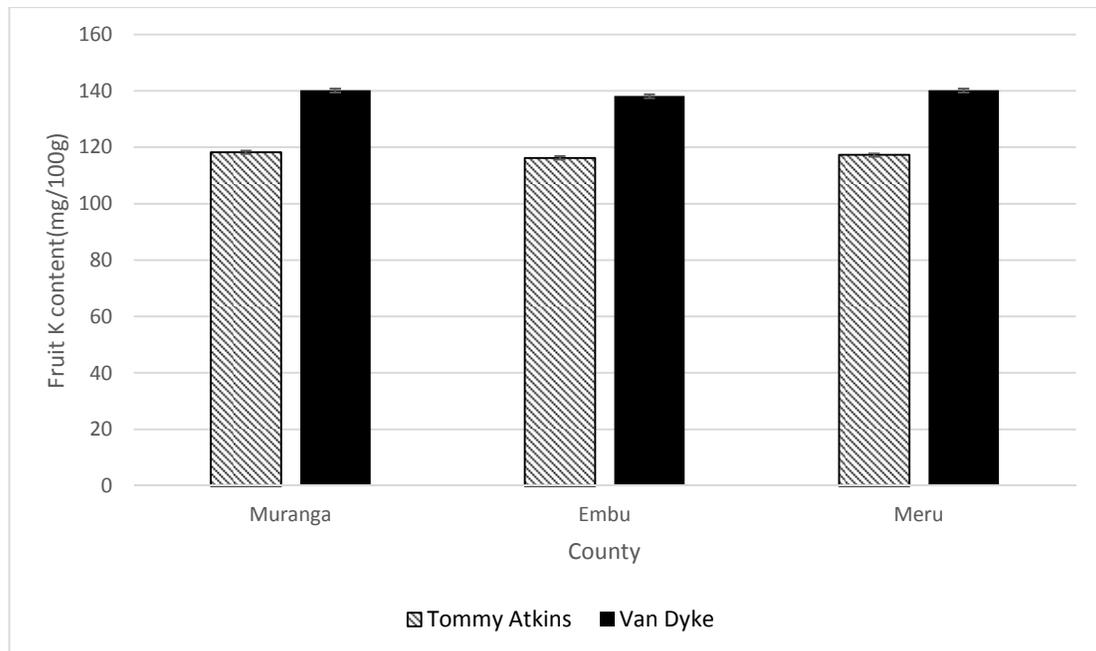
**Fig. 5. Mesocarp content of Ca content (mg/100 g) for “Tommy Atkins” and “Van Dyke” mangoes harvested from Murang’a, Embu and Meru counties (n=3;  $\pm$  = standard errors)**

less susceptible to jelly seed disorder. These authors further reported that varieties of Indian origin or their hybrids are generally more sensitive to jelly seed. It is also reported that

mango varieties whose fruits are fibrous like “Espada” and “Coquinho” are more tolerant to jelly seed while genetically improved varieties such as Van Dyke are highly susceptible [12].



**Fig. 6. Mesocarp content of Mg (mg/100 g) for “Tommy Atkins” and “Van Dyke” mangoes harvested from Murang’a, Embu and Meru counties (n=3;  $\pm$  = standard errors)**



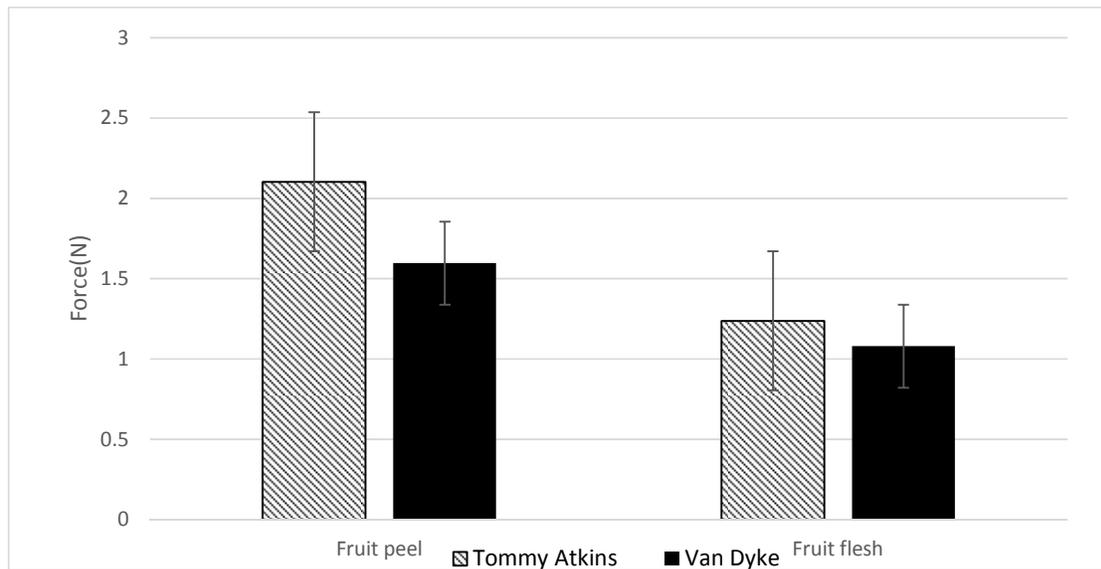
**Fig. 7. Mesocarp content of K (mg/100 g) for “Tommy Atkins” and “Van Dyke” mangoes harvested from Murang’a, Embu and Meru counties (n=3;  $\pm$  = standard errors)**

**Table 1. Mean level of Jelly seed disorder in tree-ripe fruits of “Van Dyke” and “Tommy Atkins” grown in Embu, Murang’a and Meru counties**

Variety	Jelly seed incidents in the Mesocarp		
	Embu	Murang’a	Meru
Van Dyke	2.47a	1.63a	1.05a
Tommy Atkins	1.47b	1.26b	0.88a
CV (%)	25.7	26.0	31.0

Means followed by the same letter along the column are not significantly different at  $p \leq 0.05$  according to Student-Newman-Keuls test

0=no symptoms of jelly seed; 5=almost all pulp affected



**Fig. 8. Mean force (N) of fruit peel and fruit flesh of “Tommy Atkins” and “Van Dyke” at tree ripe stage (n=3;  $\pm$  standard error)**

#### 4. CONCLUSION

It can therefore be concluded that agro-ecological conditions have a significant effect on the incidences of jelly seed as observed in the three counties studied. The incidences are also affected by inherent characteristics with some varieties (such as “Van Dyke”) being more susceptible to jelly seed than others such as “Tommy Atkins”.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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