EVALUATION OF ADAPTABILITY AND YIELD STABILITY OF SELECTED SWEET CORN VARIETIES GROWN IN RIFT VALLEY PROVINCE IN KENYA

By

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DECLARATION AND APPROVAL

Declaration

This research thesis is my original work and has not been presented for award of a degree in this or any other University. No part of this thesis may be reproduced without the prior written permission of the author and/or University of Eldoret.

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DEDICATION

This work is dedicated to my lovely wife and son Rawlings for giving me the courage to tackle this daunting task.

ABSTRACT

Food security has been of a major concern globally. In Kenya the national development Blueprint Vision 2030, envisages the eradication poverty and enhanced food security. Agricultural sector's economic importance thus cannot be over emphasized. Most research studies have laid focus on the impact of different crop management techniques on crop performance. Sweet corn is an important vegetable and commercial crop in many tropical and sub-tropical countries. It is a relative short season and moderately drought-tolerant crop that is adapted to a wide range of climates and soil characteristics (Bray, 1997). However the study on the adaptation and yield stability of sweet corn varieties grown in selected production areas in Kenya is not evident. A study was carried out using four selected varieties grown in three locations in Kenya for two seasons to assess this. The varieties selected were Chieftain, Star 7717, Pacific Queen Hybrid and a landrace. These varieties were obtained from local seed distributing agents and the farming communities. Bomet, Koibatek FTC and University of Eldoret in the Rift valley province were the selected test sites. The experiment was laid in a Randomized Complete Block Design (RCBD) with three replications. Quantitative traits measured included: the number of days to emergence, flowering and maturity. Other traits were germination percentage, the number of leaves at flowering, the plant heights, the total biomass and the yield. Qualitative traits scored were seedling vigour, leaf colour intensity and pubescence, stand-ability, snapping ease, tolerance to stress, cobs fill, husk cover and sweetness based on IPBGR maize descriptor. ANOVA of quantitative traits showed a significant variation among the varieties, seasons and locations at $p \leq 0.05$ level of confidence. It was also observed that qualitative traits varied significantly among varieties; but that variation was not evident with seasons and locations. Early seedling vigour and tolerance to stress varied significantly with both seasons and locations. Variation in both quantitative and qualitative traits indicates the influence of the environment on the performance of a variety (GXE). Adaptation and yield stability varied significantly among the varieties at $p \leq 0.05$ level of confidence. The regression coefficients (β) of the tested varieties observed were 0.81, 1.29, 0.302 and 0.04 for the varieties Pacific Queen Hybrid, Landrace, Chieftain and Star 7717 respectively. Pacific Queen Hybrid had a wider adaptation, more stable and high yielding variety across the test locations. Chieftain, Landrace and Star 7717 had lower adaptation, less stable and realized high yields in specific environment (location). Qualitative grading of environment showed Chepkoilel as being superior over Bomet and Ravine. Pacific Queen Hybrid ranked best among the tested varieties in all the test location and thus suitable for production in all the three sites. Chieftain and Star 7717 realized better yields the best Ravine while landrace was in Bomet respectively, hence these varieties can be recommended for each specific location.

TABLE OF CONTENTS

Title page i
DECLARATION AND APPROVAL ii
Declaration ii
Approval ii
DEDICATION iii
ABSTRACT iv
TABLE OF CONTENTS v
LIST OF TABLES vii
LIST OF FIGURES viii
LIST OF ABBREVIATION ix
ACKNOWLEDGEMENT x
DEFINITION OF TERMS xi
CHAPTER ONE 1
INTRODUCTION 1
1.1 Introduction 1
1.2 Problem statement 3
1.3 Justification 3
1.4 Objectives of the study 4
1.4.1 Main objective 4
1.4.2 Specific Objectives 4
1.5 Hypothesis 5
LITERATURE REVIEW 6
2.1 Introduction 6
2.2 Origin of sweet corn 6
2.2.1 Botany 6
2.2.2 Ecological requirements for growth of sweet corn 8
2.3 Breeding and genetic improvement of sweet corn 9
2.4 Adaptability of sweet corn 10
2.4.1 Importance of adaptability test of sweet corn 10
2.5 Stability of sweet corn 11
2.6 Morphological and Agronomic Traits Expression 12
2.7 Yields 13
CHAPTER THREE 15
METHODOLOGY 15
3.1 Materials and Method 15
3.1.1 Experimental Sites 15
3.1.2 Varieties of sweet corn studied 15
3.1.3 Experimental design 16
3.1.4 Crop management 16
3.2 Data Collection 16
3.3 Data Analysis 18
CHAPTER FOUR 20
4.0 RESULTS 20
4.1 Agronomic and Morphological Traits Expression 20
4.1.1.1 Phenotypic traits evaluation in Bomet 20
4.1.1.2 Phenotypic traits evaluation in Chepkoilel 25
4.1.1.3 Phenotypic traits evaluation in Ravine 29

4.1.1.4 Phenotypic traits evaluation in all locations 33
4.1.2 Qualitative traits..... 38
4.2 Genotype, environment and GEI effects 42
4.2.1 Genotype performance in each location 42
4.2.2 Genotype performance in all the location..... 43
4.3 Correlation analysis. 44
4.4 Adaptability and yield stability..... 45
CHAPTER FIVE 46
DISCUSSION..... 46
5.1. Genotype Characterization 46
5.2 Effect of environment on genotype expression 49
5.3 Correlation between Yields and other Characters 50
5.5 Adaptability and Yield Stability 50
CHAPTER SIX..... 52
6.1 Conclusion 52
6.2 Recommendation 52
CHAPTER SEVEN 53
REFERRENCE..... 53
APPENDIX..... 58

LIST OF TABLES

Table 1: Morphological descriptors used in scoring for qualitative traits.. 18

Table 2(a): Comparison of means of quantitative traits of sweet corn varieties in Bomet 23

Table 2(b): Comparison of means of quantitative traits observed with variation in season 24

Table3(a): Comparison of means of quantitative traits variation among varieties in Chepkoilel..... 27

Table 3(b): Comparison of means of quantitative traits variation with season................................ 28

Table 4(a): Comparison of means of quantitative traits variation among varieties in Ravine.......... 31

Table 4(b): Comparison of means of quantitative traits variation with season................................ 32

Table 5(a): Comparison of means of quantitative traits observed among varieties all locations...... 36

Table 5(b): Comparison of means of quantitative traits variation with location.............................. 37

Table 6(a): Comparison of means of quantitative traits variation among varieties.......................... 40

Table 6(b): Comparison of means of quantitative traits variation among the location 41

Table 7: Correlation of morphological and agronomic traits with yields 44

LIST OF FIGURES

Figure 1: Picture of freshly harvested ear 2

Figure 2: Sweet corn growing in the field at University of Eldoret 20

Figure 3:A graph representing variety mean yields of sweet corn varieties against location 45

LIST OF ABBREVIATION

ASDSP	Agriculture Sector Development Support Program
ASDS	Agricultural Sector Development Strategy
ASI	Asynchronous Silking Interval
GXE	Genotype by Environment Interaction
HCDA	Horticultural Crops Development Authority
HI	Harvest Index
MET	Multi-Environment Trials
PQH	Pacific Queen Hybrid

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DEFINITION OF TERMS

Adaptability	Ability of the plant to adjust to variable growing conditions through self-regulatory mechanism that permits stabilization in fluctuating environments
Stability	It's the characteristic of a genotype to exhibit a relatively constant yield, independent of changing environmental conditions.
Food security	Access to food that is healthful, nutritious, safe, and culturally acceptable at all times.
Yield potential	Is the maximum yield obtained in crop when grown in an environments to which it is adapted, where nutrients and water are non-limiting and with pests, diseases, weeds, lodging, and other stresses effectively controlled

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Sweet corn is an important vegetable and commercial crop in many tropical and sub-tropical countries. Worldwide Brazil, China, India, Mexico and the United States of America (USA) are the leading producers of sweet corn (FAO, 2012). It is consumed as a fresh vegetable whose fresh harvested ears are rich in energy, protein, vitamin and antioxidants that protect against age-related muscular degeneration, fighting free radicals in the eyes retina and cancerous cells in the body. Other applications includes: the manufacture of cosmetics and glucose from starch, oils, glue, paint, varnishes and paper. Sweet corn production in Africa is still at infancy stage. In Kenya, it is one the popular horticultural crops grown export market. Sweet corn exports for the 2011 was worth over Ksh. 600 million in foreign earnings (FAO, 2012).

Sweet corn is a short season and moderately drought-tolerant crop that is adapted to a wide range of climates hence a best strategy in areas faced with variation in climate and soil characteristics (Bray, 1997). The introduction of sweet corn was based on a genetic study by John Laughnan who observed that kernels with shrunked allele (***sh_2***) had 'unusually' sweet with a pleasant malty flavour. The first commercial hybrid was released 1961 (Tracy, 1977; Steffensen, 2000). Genotype by environment interaction (GXE) is a differential response of genotype(s) to varied environments (Kang, 1990 & 1998; Brancourt-Hulmel & Lecomte, 2003; Cooper & Hammer, 1996; Snijders & Van, 1991; Yan & Kang, 2003).

Optimum yields and quality of sweet corn has been observed to vary with crop genotypes or varieties and the quality of growing environment (Dragan *et al*., 2008; Öktem *et al*., 2004;

Marton *et al*., 2007; Nagy, 2007). Crop management techniques have also been cited an influence crop performance (*Dragan et al*., 2008*)*. Evaluation of genotype(s) in varied environments allows for the identification of highly adapted, stable and high-yielding genotype(s) (Kang, 1998). A significant GXE coupled magnitude changes in the genotypic yield responses of the tested genotype with variation in environments ease the selection of the best genotype(s) for specific or general environment based on their relative ranking those environments (Fernandez, 1991; Lu'quez *et al*., 2002).

The Environmental Index Model (EIM) of assessing phenotypic stability is also useful in the selection process (Eberhart & Russell, 1966). Log linear transformation of variety/genotypic mean yields and plotting them against the location allows for the measurements of adaptation and stability. Genotype(s) having high mean yield and regression co-efficient approximating to a unit ($\beta \approx 1.00$) are stable and widely adapted and while those with low mean yields and regression co-efficient ($1<\beta>1$) have specific adaptation (Romagosa & Fox, 1993).

Figure 1: Picture of freshly harvested ear
(Source: Author, 2013)

1.2 Problem statement

In Kenya the national development blueprint Vision 2030 envisage eradication of poverty and enhanced food security through increased productivity. Studies on agricultural production have often laid more emphasis on the impacts of crop management techniques and structural policy adjustments on the production of major crops (Vision 2030, 2007). Sweet corn is a popular export crop HCDA, (2008) but farmers have failed to realize the desired improvements in yield or optimum yields from hybrid seeds. There are no evident studies on evaluation of genotype(s) adaptation and yield stability tests of sweet corn varieties grown in selected production areas in Kenya.

GXE could be one of the reasons for the failure of some formal breeding programs to serve resource poor-farmers (Busey, 1983; Ceccarelli *et al*., 2006). It's a common scenario in yield trials to select only the highest yielding genotype (Gauch & Zobel, 1996). Hence genotypes that respond favourable to agricultural inputs or environments are selected; stability in this experienced under high population (Becker, 1981; Lin *et al.,* 1986). In this case the selected genotypes are not necessarily stable (Kang, 1988; Pham & Kang 1988). Thus there is a need to establish if sweet corn varieties vary in the sensitive or resistant to change in growing environmental in Kenya.

1.3 Justification

Sweet corn is a high value crop with vast industrial application and nutritional value (FAO, 2012). It is said have wide adaptation to wide range of climates including marginal areas and under deficit irrigation (Bray, 1997; Dragan *et al*., 2008) this crop would be useful in harnessed the potential of marginal areas and enhancing food security in the country. The main objectives of most formal breeding programs are wide adaptation and stable performance of genotypes (Jatasare & Paroda, 1980). However farmers have failed to realize optimum yields from these hybrid seeds; previous research findings have attributed this to genotype by environment interaction effects (GXE) (Ceccarelli *et al*., 2006; Gauch & Zobel, 1996).

Multi-Environment Trials (MET) of sweet corn varieties is vital in the selection of genotypes (Romagosa & Fox, 1993). Widely adapted, stable and high yielding varieties are suitable for production in multi-locations while those with low adaptation, less stable and high yielding in a given environment hence suitable for production in those specific environments (location/season) (Eberhart & Russell, 1966; Lu'quez *et al*., 2002). It has been observed that optimum yields and the quality of sweet corn vary with crop varieties and the growing environment (Dragan *et al*., 2008; Nagy, 2007). A qualitative grading growing environment is useful in the identification of best location for sweet corn production.

1.4 Objectives of the study

1.4.1 Main objective

To evaluate the performance, adaptation and yield stability of selected sweet corn varieties grown under varying agro ecological conditions in Kenya

1.4.2 Specific Objectives

i. To determine if the morphological traits expressions of sweet corn vary with variety and environment
ii. To determine if the yields of sweet corn vary with variety and environment
iii. To determine if the yields of sweet corn correlates with other agronomic traits
iv. To establish if the sweetness varies with genotypes and environment

1.5 Hypothesis

H_o: Morphological trait expressions of sweet corn varieties do not vary variety and environment

H_a: Morphological trait expressions of sweet corn vary variety and environment

H_o: The yields of sweet corn do not vary with variety and environment

H_a: The yield of sweet corn varies with variety and environment

H_o: Agronomic traits of sweet corn do not correlate with yields.

H_a: Agronomic traits of sweet corn correlates with yields.

H_o: Sweetness does not vary with variety and location

H_a: Sweetness varies with both variety and location

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Horticultural production in Kenya is mostly export oriented. Sweet corn is one of a high valued horticultural crop grown for export market (HCDA, 2008). It is used in the manufacture of cosmetics and glucose from starch, oils, glue, paint, varnishes and paper.. Nutritional value of sweet corn cobs includes: energy, protein, vitamin and antioxidants that protect against age-related muscular degeneration and helps fight free radicals in the retina.

2.2 Origin of sweet corn

Sweet corn is believed to have occurred as a result of spontaneous mutation in field corn. It is native crop to several American tribes. The Iroquois gave the first record of sweet corn (called Papoon) to European settlers in 1779. It soon became a popular food in southern and Central America as well as some parts of the United States. Open pollinated varieties of sweet corn become widely available in the United States in the 19th century, the most enduring varieties Country Gentleman (shoepeg) corn characterized by small, white kernels in irregular rows and Stowell's Evergreen are still available to date. Sweet corn production in the 20th century was characterized by the identification of gene mutations responsible for kernel sweetness i.e. normal sugary (***su)***, sugary enhanced (***se)*** and shrunken (sh_2) and hybridization that allowed for more uniform maturity, disease resistance and improved quality (Erwin, 1951; Tracy, 1977; Steffensen, 2000).

2.2.1 Botany

Sweet corn, *Zea mays* L. Var. Saccharata belong to the family Poaceae. It is a special corn whose sweet kernels are eaten as vegetable in contrast to traditional field corn. It is harvested when the ears are at milk stage and used when it still fresh. Sweet corn differs from the field corn due genetic mutation at the sugary (***su***) locus. They are characterized based on the type of gene mutation it contains these are: normal sugar type which contains the "sugary gene" (***su)*** whose kernels have 9-16 % sugar content, the sugary enhanced type containing "sugary enhanced gene" (***se*)** and whose kernels are tender, creamy texture with 14-35% sugar content and the super sweet type containing "shrunken gene" (***Sh_2)*** and whose kernels have 28-44% sugar content (Steffensen, 2000)

Its stem superficially resembles bamboo canes and the inter-nodes can reach 20–30cm. It has a distinct growth form; the lower leaves being like broad flags, 50–100cm long and 5–10cm wide, the stems are erect; conventionally grow up to 2–3m in high, with many nodes casting off flag-leaves at every node. Under these leaves and close to the stem grow the ears. Its fruit a caryopsis; the ears are female inflorescence, tightly covered over by several layers of leaves, and so closed-in by them to the stem that they do not show themselves easily until the emergence of the pale yellow silks from the leaf whorl at the end of the ear. The silks are elongated stigma that looks like tufts of hair, at first green and later red or yellow. The other type of sweet corn *Zea mays* L. Var ramagosa is grown for silage. It has dense foliage and fewer ear set percentage compared to other varieties (Dickerson, 2006; Davis, 1997)

Sweet corn is a facultative short-day plant whose flowering is hastened by short day (12-14 hours) and 10 degree growing days. The most popular sweet corn varieties grown in Kenya includes: chieftain, PQH and Star 7717. Seed production are done out of the country prior to importation and distribution in locally by seed companies or merchants (HCDA, 2008). The local land race is an open pollinated variety (OPV) which a direct descent of yellow dented maize that has since under gone a series of selection by the farmers who have grown them over years. Harvesting varies from pre-milk, milk, early dough, and dough stages depending on the end use and consumer tastes and preference (Nagy, 2007).

Sweet corn varieties are classified based on kernel sweetness, texture and aroma as well as desired end use. The choice of the variety to grow depends on the farmer's desired traits: enhanced yield, higher number of cobs per plant, better kernel sets and increased tolerance environmental stress. Consumers prefer varieties with better taste and preferences and kernel colour.

(Http.www.dpi.nsw.gov.au/agriculture/horticulture/vegetable/commodity/sweet-corn)

2.2.2 Ecological requirements for growth of sweet corn

Sweet corn does well in fertile, warm well-aerated and drained soil having ample moisture content and optimal level of pH 5.5 to 7. Soil temperature below 10°C inhibits germination and optimum temperature for seed germination is 21-27°C. In cool climates and short growing seasons (temperate conditions) where soil temperature is below 10°C out-door production is only possible by raise soil temperatures to 12.2ºC (Aguyoh *et al.,* 1997). It has been observed that the germination is improved by 8% when seed are sown under clear plastic mulch and the number of days to emergence hastened (11 days). Flowering and harvesting dates were also earlier by 6 to 14 days depending on the cultivars. Higher temperature is beneficial in accelerating kernel development and maturity, temperature exceeding 35°C affects the success of pollination (Yanzhe *et al*., 2007).

Flowering in sweet corn is hastened by short day and 10 degree days. Its maturity varies from variety/cultivar to cultivar and location to location but often ranges between 65-110 days after emergence. The crop does well in mid to high altitude areas; in Kenya main production areas are the lower slopes of Mount Kenya, South, Central and Northern slopes of the Rift valley. Njoro canning factory, Everest Company Ltd, Mayfield growers & exporters, and Global fresh ltd among others are the main producers and exporters of this crop (HCDA, 2008).

2.3 Breeding and genetic improvement of sweet corn

The history of breeding and genetic improvement of maize started in pre-historical period where large plants producing large ears were selected. Modern breeding however began with individuals who selected highly productive varieties in their fields and then sold seeds to other farmers. James L. Reid was one of the earliest and most successful individual to develop Reid's Yellow Dent in the 1860s. These early efforts were based on mass selection. Later on the breeding efforts changed to include ear to row selection Hopkins in1896, hybrids made from selected inbred lines Shull in1909 but the first successful double cross hybrids using 4 inbred lines was done by Jones 1918-1922 as reported in the work of (Tracy, 1977; Steffensen, 2000).

Long term development and production of hybrid maize seeds started in 1930’s (Jugenheimer, 1958). However sweet corn breeding is the most recent development that started in the 1950’s based on the invention of super sweet corn by John Laughnan (Steffensen, 2000; Tracy, 1977). His work originated from a genetic study in which he observed that kernels having *shrunken* (***sh*$_2$*)* *allele* were 'unusually' sweet often having a pleasant malty flavour. His breeding program resulted in the development and release of the first commercially acceptable hybrid in 1961. Later on breeding by Wolf of the University of Florida also contributed to the success of super sweet corn (Steffensen, 2000; Tracy, 1977).

Horticultural and agronomic crops differ in their genetic improvement objectives. In agronomic the breeding objectives are grower directed traits includes: increased yield, resistance to stress and increased yield stability under high populations in contrast to horticultural breeding where the objectives are consumer directed such as taste and other quality aspects (Janick, 2005). The grower-directed traits can be solved by non-genetic means, whereas consumer-directed traits especially quality are genetic means (Janick, 2005).

2.4 Adaptability of sweet corn

Sweet corn is said to be a short season and moderately drought-tolerant crop that is adapted to a wide range of climates. Its production and cultivation rather than vegetables, is the most effective strategy in areas facing climate changes and soil characteristics (Bray, 1997). Genotype x environment interaction (GXE) is important in genotype testing programs since genotype adaptation is subject to influence by the environment (Becker & Leon, 1988). Genotypes that exhibit a constant value with minimal variance of the measured traits, independent of changing environments are consider to be widely adapted and stable i.e. have greater resistance to environmental stress (Becker & Leon, 1988).

The breeding objective of most programs wide adaptation and stable performance of genotypes (Jatasare & Paroda, 1980). The study of the genotype(s) adaptation using a scatter diagram involves plotting mean value of a variety trait measured against the location (Jatasare & Paroda, 1980; Finlay &Wilkinson, 1963). Wide variation would be evident with genotype sensitivity/resistance to environment stress as characterized by the regression co-efficient (β) (Romagosa & Fox, 1993; Jatasare & Paroda, 1980; Eberhart & Russel, 1966). Similarly the degree of adaptation to varied environments might be evident with seasons (Finlay & Wilkinson, 1963).

2.4.1 Importance of adaptability test of sweet corn

Multi-Environment Trials (MET) is essential in any selection process and it is through this that the sweet corn varieties having wide or specific adaptation can be identified and recommended for these locations (Blanche & Myers, 2006; Epinat-Le *et al*., 2001).

Widely adapted and stable possess greater resistance to environmental stress or increased specificity of adaptation to low yielding environments (Becker & Leon, 1988). MET is useful in distinguishing between favourable and non-favourable seasons and discriminating and none discrimination locations through quantitative grading of the seasons or location (Blanche & Myers, 2006; Finlay & Wilkinson, 1963).

2.5 Stability of sweet corn

Genotype x environment interaction (GXE) is characterized by the differential response of genotypes to diverse environments (Kang, 2002; Brancourt-Hulmel & Lecomte, 2003; Yan & Kang, 2003; Kang 1998; Cooper &Hammer, 1996; Snijders & Van, 1991; Kang 1990). GXE complicates the selection of superior genotypes (Magari & Kang, 1993). Stability measures reduce correlation between phenotypic and genotypic values, thereby reducing progress from selection in breeding programs (Comstock & Moll, 1963).

Multi-environment trials (MET) offers for differentiation of genotypic response to varied environments, especially in case where changes in genotypic ranking is not evident, hinders selection of superior and stable hybrids (Blanche & Myers, 2006; Epinat-Le *et al*., 2001; Xing *et al*., 2007). Lu'quez *et al*., (2002) observed that the most stable and highest yielding cultivars can be identified by growing cultivars in a set of environments. Plant breeders prefer non-cross over effects GXE or preferably the absence of GXE in the selection of stable genotype. Thus, the estimation of genotypes stability becomes important in identifying the most consistent-performing and high-yielding genotypes Kang, (1998) and from the farmers' standpoint, the agronomic where yield stability is enhanced under high population is important (Lin *et al*., 1986).

Stability statistics are used to determine whether cultivars evaluated under MET are stable or not (Hussein *et al*., 2000; Lin *et al*., 1986; Flores *et al*., 1998). Stable genotype(s) are not necessarily the highest yielding, thus methods that integrate yield potential and stability are useful in the selection of superior genotypes (Kang, 1988; and Pham & Kang, 1988). The GXE can be properly exploited to the breeder's advantage through various approaches Yan & Kang, (2003) such as parametric analysis approach that is based on statistical assumptions about the distribution of genotype, environmental and GXE effects (Yan & Kang, 2003; Annicchiarico, 2002; Kang 1998; Gauch & Zobel, 1996). The measures of phenotypic stability are based their variance components or related statistics these estimates have good properties in the absence of outliers effects and under assumption that distribution of errors and interaction effects are normal.

This statistical model is similar to Environmental Index Model (EIM) of assessing phenotypic stability of genotypes (Eberhart & Russell, 1966). Regression analysis can be also used in measuring genotype stability (Romagosa & Fox, 1993; Finlay & Wilkinson, 1963). There is a need to have log transformed data so as to induce a high degree of linearity. Genotype whose regression co-efficient is approximating to a unit ($\beta \approx 1.0$) coupled with high mean yield have an above average stability while those having regression co-efficient greater than or below a unit have below average stability (Lu'quez *et al*., 2002; Romagosa & Fox, 1993; Eberhart & Russell, 1966; Finlay & Wilkinson, 1963).

2.6 Morphological and Agronomic Traits Expression

Quantitative traits expression is a complex of genotype, quality of the growing environment and their interaction i.e. quantitative genetic theory (Fehr, 1987). Viswanatha *et al*., (2002) observed that the expression morphological traits in sweet corn are influence by the quality of the growing environment. He observed that the yields decreased with reduction irrigation water and between 22.6 - 26.4% reductions was recorded under deficit irrigation. This was characterized by a reduction in kernel set, kernel weight, total biomass, and vigour as evident under such watering regime. Sweet corn quality varies both with variety and environment (Marton *et al*., 2007; Nagy, 2007). Agronomic and economically important traits often exhibit GEI effects. GEI with a significant magnitude changes in genotypic means across different environment(s) or from changes in the relative ranking of such genotype(s) in different environments/seasons (Fernandez, 1991).

2.7 Yields

A study done in Slovenia showed the benefit of sweet corn production in sandy-loam as earlier harvesting, while that of growing in clay-loam was late harvesting but ultimately higher yields realized (Dragan *et al*., 2008). This crop has been shown do well under deficit irrigation though water deficiency affected the yield, with highest yields being obtained under full irrigation treatments (Dagdelen *et al*., 2006; Viswanatha *et al*., 2002). It was observed that yields decreased with reduction in irrigation water by 22.6 - 26.4% as a result of reduction in the number of kernel set and cob weight (Pandey *et al*., 2000). The variation in climate and soil characteristics influences crop productivity. Crop management too influences the yield potential (*Dragan et al*., 2008*)*. Grain yield reduction of 37% was due to 18% decline in the kernel weight and 10% in kernel number under water stress conditions (Viswanatha *et al.*, 2002; Pandey *et al*., 2000). Optimum yields and quality variations in sweet corn is evident with changing environments and crop varieties (Dragan *et al*., 2008; Marton *et al*., 2007; Nagy, 2007; Bódi *et al*., 2006; Buzás *et al*., 2006; Hadi, 2005; Öktem *et al*., 2004; Kwabiah, 2004). Yield and yield components being quantitative in nature routinely exhibit a significant GXE (Fehr, 1987).

Gauch and Zobel, (1996) observed that a significant GXE is ignored most yield trials and thus the selected genotypes may not be Kang, (1988). This could be the reason for the failure of some formal breeding to serve small, resource-poor farmers (Ceccarelli *et al*., 2006). Genetic variability of crop genotypes is vividly expressed during MET Busey, (1983) and thus the identification genotypes stable and highly adapted or those which are less stable and have specific adaptation to test environments (location) in Kenya (Kang *et al.,* 2004; Annicchiarico, 2002). Adaptability and stability measures also allows for quantitative grading of the growing environment (Romagosa & Fox, 1993).

CHAPTER THREE

METHODOLOGY

3.1 Materials and Method

3.1.1 Experimental Sites

A field study was conducted in three selected sites: University of Eldoret (Chepkoilel), Koibatek FTC and Bomet. These target sites were selected from within sweet corn growing areas with varied environmental conditions and soil characteristics. From each site a random soil sample was obtained from the experimental plots, using a ziz - zag method where soil up to 30 cm deep was collected using a soil auger. The soil samples were then through mixed to obtain a composite sample. A composite sample weighing 1 kg was bagged, labelled and taken to the laboratory for analysis, here the soil sample was air dried to reduce moisture content and later oven dried for 48-72 hours. Samples were analysed to determine its pH and soil textural class. The air temperature, amount of rainfall, latitude and altitude from the trial sites were obtained recorded for each site.

3.1.2 Varieties of sweet corn studied

The selection of varieties was based on market availability, farmer's choices, consumer tastes and preference. Farmer prefer varieties that are high yielding and stable i.e. agronomic stability that is those varieties that have better response to favourable environment/season and or agricultural inputs as well as resistant/tolerant to environmental stress (biotic and a biotic) (Lin *et al.,* 1986). Consumers on the other hand beg their choices on good quality, longer storage, amount of sugar content and eating quality i.e. tastes/preference (Nagy, 2007; Diver *et al.,* 2001).

The most common varieties grown in Kenya includes: chieftain bicolour, star 7717, PQH and a local land race. These varieties sourced from Pannar seed, EA Seed Company and a land race obtained from the local farming communities respectively. It worth to that the sweet corn hybrids are not produced in the country but rather imported from outside (HCDA, 2008). The said varieties were then selected for this study.

3.1.3 Experimental design

Four varieties were studied in a Randomized Complete Block Design (RCBD) having three replicates. This experiment ran for two seasons: long rains (April-August 2011) and short rains (October 2011-Februay 2012). Each experimental plot measured 4m x 3m.

3.1.4 Crop management

Land preparation involved clearing the vegetation after which primary and secondary cultivation was done in prior to planting. Planting was done at onset of rains with an inter-row spacing of 70 cm and intra-row spacing of 20 cm. The depth of the planting hole was 50mm and the fertilizer application rate of 80 kg P/50N during planting and 160N applied as top dress when the crop was knee high. Weeding was done when the plants had four true leaves while a pesticide was applied to control stem borer and ear corn worm. Harvesting was done at the milk stage.

3.2 Data Collection

In each experimental plot five plants were selected at random from the two inner rows and the data on these parameters collected. These included: the number of days to emergence was obtained through counting the number of days taken from the planting date of planting to when seedling emergence. Germination percentage was obtained from field counts of seeds that emerged as a percentage of the seeds sown. The number of days to flowering and maturity were measured by counting taking into account the time of planting up to time, 50%

of the plants flowered or they are ready for harvesting. Similarly numbers of leaves at flowering obtained by counting the number of full leaves when at least 50% of the plants have flowered.

The ear height, height at flowering and height at maturity were obtained through direct measurement of the said trait using a measuring tape. Cob weight was obtained by removing the husk on a fresh harvested ear and then weighing using a sensitive scale in the laboratory. The length of the cob and its equatorial diameter was measured using a ruler while the total biomass was obtained by having all above roots foliage harvested, bagged and taken for measurements in the laboratory. Morphological traits scored included seed texture, seedling vigour, leaf colour intensity, pubescence, stand-ability, snapping eases, cobs filling, husk cover and stress tolerance/resistance. These traits were scored based on IPBGR (1991) maize descriptors.

The sweetness was scored as being sugary, sweet or very sweet. A random sample of respondents was selected in each tested site. Respondent was given fresh boiled cob and asked to rate them based on the scale above. Yield stability on the other hand was measured by calculating the regression coefficients of the graph of log transformed mean yield of sweet corn varieties plotted against location (Romagosa & Fox, 1993).

Table 1: Morphological descriptors used in scoring for qualitative traits

Morphological descriptor	Score
Leaf colour intensity	3 Light green 5 green 7 dark green
Ear husk cover	3 Poor 5 Good 7 Excellent
Kernel colour	1 Single 3 Bi-colour 5 Multi-colour
Pubescence	3 Sparse 5 Intermediate 7 Dense
Snapping ease	3 Hard 5 Easy 7 Very easy
Seedling vigour	1 Poor 3 Fair 5 Good 7excelllent
Seed texture	1 Smooth 2 Partially rough 3 Radially rough 4 Partly radially rough 5 Reticulate rough
Cobs fill	1 incomplete 3 complete
Stress tolerance	1 Poor 3 Fair 5 Good 7 Excellent
Sweetness	3 Sugary 5 Sweet 7 Very sweet
Stand-ability	3 poor 5 Good 7 Excellent
Cob shape	3 oblong without taper 4 oblong with slight taper 4 cylindrical with slight taper 5cylindrical with pronounced taper
Plant height	1 Short (<1.5m) 3 Medium (1.5-2m) 5 Tall (>2m)

Source: Maize IBPGR descriptors (1991)

3.3 Data Analysis

Quantitative traits measured were subjected to analysis of variance (ANOVA) using Genstat statistical program version 12. The means of variety and season in each location were compared to determine if there was a significant variation among the tested varieties and seasons at $p \leq 0.05$ level of confidence. The means of variety and locations were compared to determine if there was a significant variation among the tested varieties and location at $p \leq$

0.05 level of confidence. Fisher's LSD was used to confirm if the means for variety, location and season varied significant at 95 % level of confidence.

Qualitative traits on the other hand had their scores subjected to analysis of variance (ANOVA). The means of variety and location were compared to determine if there was a significant variation among the tested varieties and location at $p \leq 0.05$ level of confidence. This means of the varieties and location were compared using Fisher's least significant difference (LSD) method to test they were significant at 95 % level of confidence.

The general linear model for individual site was:

$$\mathbf{X_{ijkl}=\mu + t_i+\beta_j + \gamma_{il}+\delta_{ijk}}$$

Where: $\mathbf{X_{ijk}}$ Individual plot observation for a given trait

$\boldsymbol{\mu}$ Sites overall mean

$\mathbf{t_i}$ Variety effect

$\boldsymbol{\beta_j}$ Season effect

$\boldsymbol{\gamma_l}$ Variety x season interaction

$\boldsymbol{\delta_{ijk}}$ Residual error effect

The general linear model for all the sites was:

$$\mathbf{X_{ijkl}=\mu + \pi_i+ \beta_j + \gamma_{il}+\delta_{ijk}}$$

Where: $\mathbf{X_{ijk}}$ Individual site observation for a given trait

$\boldsymbol{\mu}$ Sites overall mean

π_i Variety effect

$\boldsymbol{\beta_j}$ Location effect

γ_{il} Variety x location interaction

$\boldsymbol{\delta_{ijk}}$ Residual error effect

CHAPTER FOUR

4.0 RESULTS

4.1 Agronomic and Morphological Traits Expression

4.1.1 Quantitative traits

These results of ANOVA and the separation of means tables observed for the tested sweet corn varieties evaluated in tests in three test sites **Tables 2-6.** Testing of significance for variety effects, season effect, variety x season and variety x location interaction were set at 95% level confidence.

Title: Sweet corn varieties at different developmental stages in University of Eldoret

Figure 2: Sweet corn growing in the field at University of Eldoret

(Source: Author, 2013)

Figure 2 above shows varieties at different developmental stages with PQH on the front right at the centre first column is chieftain with Star 7717 behind and on the far left is landrace.

4.1.1.1 Phenotypic traits evaluation in Bomet

The germination percentage varied significantly among tested varieties and season at p ≤0.05 level of significance; the variation among varieties in in season one were 61, 81, 82 and 75 % respectively for chieftain, landrace, PQH and star 7717 however in the second season 64, 77, 84 and 78% respectively were observed for tested varieties. The number of days to emergence varied significantly among tested varieties and season at p ≤0.05 level of significance. Chieftain emerged early, 8 days to emerge compared to 10, 10 and 12 days for star 7717 PQH and landrace respectively **Table 2(a).** The seasonal variation in the number of days to emergence of 2-4 days was observed among the tested varieties **Table 2(b).** Early emergence was observed in season two there were 7, 8, 9 and 10 days after planting for chieftain, PQH, star 7717 and landrace compared to season one which had 9, 12, 11 and 14 days after planting for the said varieties i.e. (chieftain, PQH, star 7717 and landrace respectively) **Table 2(b).**

The number of days to flowering varied significantly among tested varieties and season at p ≤0.05 level of significance. These were 56 58, 82 and 104 days for chieftain, star 7717, PQH and landrace respectively in season one compared to 48, 54, 76 and 104 days for chieftain, star 7717, PQH and landrace in season two. The number of days to maturity also varied significantly among tested varieties and season at p ≤0.05 level of significance; the variation was also evident with variation in season. The means observed in season one were 94, 100, 102 and 130 days compared to 90, 96, 96 and 122 days in season two for chieftain, star 7717, PQH and landrace. Yields varied significantly among varieties at p ≤0.05 level of significance with PQH posting the highest yield (6.7 ton ha^{-1}) and lowest yields (4.1 ton ha^{-1}) was observed in chieftain and star 7717. The mean yield observed in season one were 5.6, 7.6, 8 and 5.2 ton ha^{-1} compared 2.6, 4.2, 5.4 and 3 ton ha^{-1} observed in season two for chieftain, landrace, PQH and star 7717 respectively.

The total biomass (TWW) varied significantly among tested varieties and season at p ≤0.05 level of significance these were 7.9, 16.7, 8.6 and 6.8 ton ha^{-1} in season one compared to 5.5, 6.1, 7.8 and 5.8 ton ha^{-1} were observed in season two for sweet corn varieties chieftain, landrace, PQH and star 7717. The seasonal means was 10 and 6.3 ton ha^{-1} for season one and two respectively. Similarly ear height varied from 32.3 cm, 102 cm, 58.4 cm and 52.1 cm in season one and 31.5 cm, 94 cm, 46.6 cm and 44.3 cm in season two for chieftain, landrace, PQH and star 7717. The means for season were 61.2 cm and 54.1 cm for season one and two respectively. Height at flowering also varied among the tested varieties; the heights observed were 64.2 cm, 116.3 cm, 70.9 cm and 78 cm in the first season compared to 53.4 cm, 105.1 cm, 62.7 cm and 77.2 cm for chieftain, landrace, PQH and star 7717 respectively in the second season. Seasonal means were 82.3 cm and 74.4 cm in season one and two respectively.

Height at maturity varied with variety and season. It was observed the height of chieftain, landrace, PQH and star 7717 were 1 m, 2.5 m, 1.6 m and 1.3 m respectively season one compared to 0.9 m, 2.3 m, 1.4 m and 1.2 m observed in season two. The variation among season was 82.3 cm and 74.4 cm respectively. The number of leaves at flowering, number of rows and number of columns as well as the cobs equatorial diameter, length, weight, varied with season and among the tested varieties at $p \leq 0.05$ level of significance.

Table 2(a): Comparison of means of quantitative traits of sweet corn varieties in Bomet

Variety	Germ %	DEM	DFLR	DTM	HT FLR	HTM	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Chieftain	62.5a	8a	52a	92a	58.8a	95.5a	31.9a	10a	6.7b	24.3ab	3.3a	13.3a	148.9a	4.1a
Landrace	79c	12c	101d	126d	110.7c	238.7d	98c	14d	11.4d	26.7b	5c	19.5d	213.9d	5.9b
PQH	83.3d	10b	78c	99c	66.8ab	151.1c	52.5b	11.3b	8.2c	29.3b	4.3b	17.9c	210.8cd	6.7c
Star 7717	76.5b	10b	56b	98b	77.6b	125.2b	48.2b	12c	6.3a	23.3a	3.6a	13.7b	142.7b	4.1a
Grand mean	75.3	9.9	72	104	78.5	152.6	57.6	11.8	8.2	25.9	4.1	16	179.1	5.2
SED	1.8	0.2	0.4	0.4	5.9	4.7	2.0	0.3	0.2	1.3	0.2	0.7	6.5	0.2
LSD	3.9	0.5	1.0	0.8	12.6	9.9	4.2	0.7	0.4	2.8	0.4	1.6	13.7	0.3

Table 2(b): Comparison of means of quantitative traits observed with variation in season

Variety	Germ %	DEM	DFLR	DTM	HT FLR	HTM (cm)	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Season one	79.3a	12b	73b	107b	82.3b	158.8 b	61.2a	11.8a	10b	27b	3.9a	16.8b	192.6 b	6.6b
Season two	71.4a	9a	69a	101a	74.4a	146.4 a	54.1a	11.8a	6.3a	24.8a	4.2b	15.2a	165.6 a	3.8a
SED	1.3	0.17	0.33	0.25	4.19	3.30	1.4	0.24	0.2	0.9	0.1	0.5	4.3	0.2
LSD	2.7	0.5	0.71	0.53	8.9	7.0	3.0	0.5	0.4	2	0.2	1.1	9.7	0.4
CV%	4.2	4.1	1.1	1.0	13.1	5.3	6	4.9	4.4	8.9	4.2	4.6	4.2	7.8

Germination percentage (Germ), Number of days to emergence (DEM), Number of days to flowering (DFLR), Number of days to maturity (DTM), Height at flowering (HTFLR), Height at maturity (HTM), Height to the ear (HT ear), Number of leaves at flowering (LVFLR), Total wet weight (TWW), Cob diameter (cob dmt), Cob length (cob lgt), Cob weight (cob wgt) and Yield tonnes/ hectare (Yields t/ha).

Means were separated using Fisher LSD method; different letters within a column exhibits a significant variation in traits at $p \leq 0.05$.

*** denote significant variation at $p \leq 0.05$**

4.1.1.2 Phenotypic traits evaluation in Chepkoilel

The germination percentage varied significantly among tested varieties at p ≤0.05 level of significance. It was observed that the germination varied among varieties in season one with 68, 73, 74 and 76 % observed for chieftain, landrace, PQH and star 7717 compared to 68, 77, 82 and 80% respective observed in the second season **Table 3(a).** Seasonal means were observed to be 71 and 77 % in season one and two respectively **Table 3(b).** The number of days to emergence varied significantly among tested varieties and season at p ≤0.05 level of significance. Early emergence was observed in chieftain, 6 days after planting compared to 8, 9 and 13 days after planting for star 7717, PQH and landrace compared to 6, 7, 8 and 9 days observed in season two. Seasonal means of 9 and 8 days were observed for season one and two respectively **Table 3(b).**

The number of days to 50% flowering varied significantly among tested varieties and season at p ≤0.05 level of significance. These were 52 56, 74 and 98 days for chieftain, star 7717, PQH and landrace respectively in season one compared to 48, 52, 66 and 90 days for chieftain, star 7717, PQH and landrace in season two **Table 3(a).** The seasonal variation in the number of days to emergence of 2-4 days was observed among the tested varieties with means 96 days and 89 days observed in season one and two respectively **Table 3(b).** The number of days to maturity also varied significantly among tested varieties and season at p ≤0.05 level of significance. It was observed that the number of days to maturity were 89, 94, 102 and 120 days in season one compared to 81, 88, 96 and 114 days in season two for chieftain, star 7717, PQH and landrace respectively **Table 3(a).** Seasonal variation observed were 100 and 96 days in season one and two respectively **Table 3(b).**

Total biomass (TWW) varied significantly among tested varieties and season at p ≤0.05 level of significance. Total wet weight observed for chieftain, landrace, PQH and star 7717 were 8, 15.1, 9.8 and 7.6 ton ha^{-1} in season one compared to 6.2, 10.3, 7.8 and 6.6 ton ha^{-1} observed in season two. The season mean were 10.1 and 7.7 ton ha^{-1} in season one and two respectively. Yields varied significantly among genotypes p ≤0.05 level of significance with PQH posting the highest yield (6.9 ton ha^{-1}) and lowest yields (5 ton ha^{-1}) was observed in star 7717. It was observed that the mean yields in season one were 6.4, 6.7, 7.3 and 6.9 ton ha^{-1} for chieftain, landrace, PQH and star 7717 respectively compared to recorded 4.2, 4.3, 6.5 and 5.5 ton ha^{-1} in the season two.

Evident variation was also observed for ear height where the mean heights of 36 cm, 121.3 cm, 81.2 cm and 58.7 cm were observed in season one compared to 32.8 cm. 114.5 cm, 76.6 cm and 50.3 cm in season two for chieftain, landrace, PQH and star 7717 respectively. The seasonal means were 74.4 cm and 68.8 cm in season one and two. The height at flowering also varied both variety and season; here it was observed that plant height at flowering were 58.3 cm, 139.7 cm, 135.1 cm and 68.9 cm for chieftain, landrace, PQH and star 7717 in season one compared to 48.1 cm, 125.5 cm, 122.3 cm and 60.5 cm in season two. The mean seasonal variation in the height at flowering was 100.5 cm and 89 cm in season one and two respectively. The height at maturity also varied significantly at $p \leq 0.05$ level of significance for both variety and season with a mean height of 103.2 cm, 242.1 cm, 201.8 cm and 152.6 cm in the first season for chieftain, landrace, PQH and star 7717 respectively compared to 98.6 cm, 221.3 cm, 189.8 cm and 118 cm in season two for chieftain, landrace, PQH and star 7717. The mean height variation in height of 174.9 cm in season one compared to 156.9 cm in season two.

Similarly other traits such as the number of leaves at flowering, the cobs equatorial diameter, length, weight, number of rows and number of columns also varied with among the tested varieties and season at $p \leq 0.05$ level of significance **Table 3(a)** and **3(b).**

Table 3(a): Comparison of means of quantitative traits variation among varieties in Chepkoilel

Variety	Germ	DEM	DF LR	DTM	HT FLR	HTM	HT Ear	LV FLR	TWW ton ha^{-1}	Row	Cob Dmt	Cob Lgt	Cob Wgt	Yield ton ha^{-1}
Chieftain	65a	6a	50a	85a	53.5a	100.9a	34.4a	11.3b	7.1a	26.3a	4.2ab	16.2a	187.4a	5.3a
Landrace	75b	11c	94d	117d	132.6c	231.7d	117.9d	14c	12.7c	28a	5.3c	17a	214.9a	5.5a
PQH	78c	8b	70c	99c	128.7bc	195.8c	78.9c	10a	8.8b	31b	4.8b	20.2c	215.5a	6.9b
Star 7717	78c	8b	54b	91b	64.7a	135.3b	54.6b	12b	7.1a	27.7a	3.8a	18.5b	188.6a	5.5a
GM	74	8	67	98	94.9	165.9	71.4	11.8	9	28.3	4.5	18	201.6a	5.9
SED	3.3	0.5	1	1	6.7	5.9	7	0.3	0.6	1.2	0.3	0.6	14.16b	0.4
LSD	7	1.1	2	2.1	14.1	12.6	14.9	0.7	1.2	2.5	0.7	1.3	30.01	0.7

Table 3(b): Comparison of means of quantitative traits variation with season

Variety	**Germ %**	**DEM**	**DFLR**	**DTM**	**HT FLR**	**HTM**	**HT Ear**	**LV FLR**	**TWW ton ha^{-1}**	**Row**	**Cob dmt**	**Cob Lgt**	**Cob Wgt**	**Yield ton ha^{-1}**
Season one	71a	9b	70b	101b	100.5b	174.9b	74.4a	11.83a	10.1b	30.3b	4.5a	18.7b	226.3b	6.8b
Season two	77b	8a	64a	95a	89a	156.9a	68.5a	11.83a	7.7a	26.2a	4.5a	17.3a	176.9a	5a
SED	2.3	0.4	0.7	0.7	4.7	4.2	5	0.2	0.4	0.8	0.2	0.4	10	0.4
LSD	5	0.8	1.4	1.5	10	8.9	10.5	0.5	0.6	1.7	0.5	0.9	21.2	0.6
CV%	7.7	11.2	2.4	1.8	12.1	17.8	17	10	12.2	7.1	12.5	5.8	12	11

Germination percentage (Germ), Number of days to emergence (DEM), Number of days to flowering (DFLR), Number of days to maturity (DTM), Height at flowering (HTFLR), Height at maturity (HTM), Height to the ear (HT ear), Number of leaves at flowering (LVFLR), Total wet weight (TWW), Cob diameter (cob dmt), Cob length (cob lgt), Cob weight (cob wgt) and Yield tonnes/ hectare (Yields t/ha).

Means were separated using Fisher LSD method; different letters within a column exhibits a significant variation in traits at $p \leq 0.05$.

4.1.1.3 Phenotypic traits evaluation in Ravine

The germination percentage varied significantly among tested varieties at $p \leq 0.05$ level of significance; the variation among varieties and season. It was observed that the germination percentage varied among varieties in season one these were 62, 80, 78 and 74% respectively for chieftain, landrace, PQH and star 7717 compared to 72, 84, 86 and 84% observed in season two **Table 4(a).** Mean seasonal variation was 73.5% and 81.5 % in season one and two respectively. Tested varieties varied in the number of days to emergence with chieftain having a mean of 6 days and 10, 11 and 12 days for star 7717, PQH and landrace respectively compared to 6, 6, 7 and 8 days for chieftain, PQH, star 7717 and landrace observed in season two. The seasonal means emergence was 10 and 7 days respectively **Table 4(b).**

The number of days to 50% flowering varied significantly among tested varieties and season at $p \leq 0.05$ level of significance. These were 52 58, 74 and 96 days for chieftain, star 7717, PQH and landrace respectively in season one compared to 48, 50, 62 and 92 days for chieftain, star 7717, PQH and landrace in season two **Table 5(a).** The seasonal variation in the number of days to flowering was 70 days and 63 days for season one and two respectively Table 5(b). The number of days to maturity also varied significantly among tested varieties and season at $p \leq 0.05$ level of significance. This variation was evident in the means 89, 92, 102 and 121 days observed in season one compared to 81, 88, 96 and 113 days observed in season two for chieftain, star 7717, PQH and landrace **Table 4(a)** and **Table 4 (b).** The seasonal means were 101days and 95 days in season one and two respectively Table 4(b).

The total biomass (TWW) varied significantly among tested varieties and season at $p \leq 0.05$ level of significance. In season one the mean biomass accumulated was 7.7, 14.6, 10.9 and 8 ton ha^{-1} for chieftain, landrace, PQH and star 7717 observed in season one compared to 5.3, 9, 8.3 and 7.2 ton ha^{-1} observed in season two respectively. The seasonal means was 10.3 ton ha^{-1} and 7.5 ton ha^{-1} in season one and two respectively. Yields varied significantly among genotypes $p \leq 0.05$ level of significance with PQH posting the highest yield (6.3 ton ha^{-1}) and lowest yields (3.9 ton ha^{-1}) was observed in chieftain. The yield of the tested varieties were 5, 4.9, 6.8 and 5.1 ton ha^{-1} in season one compared to 2.8, 3.1, 5.8 and 2.9 ton ha^{-1} observed in season two for chieftain, landrace, PQH and star 7717 respectively.

Ear height varied significantly among varieties and season. The ear heights observed were 36.5 cm, 121 cm, 63.3 cm and 58 cm in season one compared to 33.3 cm, 90.2 cm, 54.1 cm and 51.4 cm observed in season two for chieftain, landrace, PQH and star 7717 respectively. Their means seasonal variation was 69.7 cm and 57.3 cm for season one and two respectively. The height at flowering varied among varieties and season. It was observed that the height at flowering was 92.1 cm, 136.8 cm, 121 cm and 115.6 cm for chieftain, landrace, PQH and star 7717 in season one compared to 82.9cm, 123.4cm, 110cm and 105.9cm posted in season two. The mean seasonal variation in the height at flowering was 116.4 cm and 105.9 cm for season one and two respectively. The height at maturity varied significantly at $p \leq 0.05$ level of significance for both variety and season. This were 142.7 cm, 273.4 cm, 172.1 cm and 132.5 cm in the first season for chieftain, landrace, PQH and star 7717 and 117.5 cm, 246 cm, 161.1 cm and 125.3 cm observed in season two for chieftain, landrace, PQH and star 7717 respectively. The mean seasonal variation was 180.2 cm in season one and 162.5 cm in season two.

Similarly the number of leaves at flowering, the cobs equatorial diameter, length, weight, number of rows and number of columns also varied with among the tested varieties and season at $p \leq 0.05$ level of significance **Table 4(a)** and **Table 4(b).**

Table 4(a): Comparison of means of quantitative traits variation among varieties in Ravine

Variety	Germ %	DEM	DFLR	DTM	HT FLR	HTM	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Chieftain	67a	6a	50a	85a	87.5a	130.1b	34.9a	10a	6.5a	18.7	3.8a	13.5a	143.2a	3.9a
Landrace	82c	10d	94d	117d	130.1c	259.7d	105.6c	13c	11.8c	17.3	4.4b	14.2a	142.4a	4b
PQH	82c	9c	70c	99c	115.5b	166.6c	58.7b	11.3b	9.6b	31	4.8b	19.6b	241.8c	6.3c
Star 7717	79b	8b	54b	90b	111.4b	128.9a	54.7b	12b	7.6a	22	3.8a	14.7a	163.7a	4b
GM	77	8	67	97.8	111.2	164.6	63.5	11.6b	8.8	22.3	4.2	15.6	172.8b	4.5
SED	2	0.4	0.9	1.1	5.21	4.57	2.0	0.4	0.6	1	0.2	0.9	16.5	0.2
LSD	4.2	0.9	2	2.3	11.1	9.69	4.2	0.9	1.1	2.1	0.3	1.9	34.9	0.5

Table 4(b): Comparison of means of quantitative traits variation with season

Variety	Germ	DEM	DFLR	DTM	HT FLR	HTM	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Season one	73.5a	10b	70b	101b	116.4b	180.2b	69.7b	12.6b	10.3b	27.2b	4.5b	16.2a	204.1b	5.5b
Season two	81.5b	7a	63a	95a	105.9a	162.5a	57.3a	11.6a	7.5a	17.3a	3.9a	15a	141.4a	3.7a
SED	1.4	0.3	0.7	0.8	3.7	3.2	14.2	0.3	0.4	0.7	0.1	0.6	11.6	0.2
LSD	2.9	0.6	1.4	1.6	7.4	6.9	3	0.7	0.6	1.5	0.2	1.3	24.7	0.4
CV%	4.4	8.7	2.4	1.9	8.1	4.5	5.5	6.6	10.8	7.6	6.7	9.9	16.5	11.1

Germination percentage (Germ%), Number of days to emergence (DEM), Number of days to flowering (DFLR), Number of days to maturity (DTM), Height at flowering (HTFLR), Height at maturity (HTM), Height to the ear (HT ear), Number of leaves at flowering (LVFLR), Total wet weight (TWW), Cob diameter (cob dmt), Cob length (cob lgt), Cob weight (cob wgt) and Yield tonnes/ hectare (Yields t/ha).

Means were separated using Fisher LSD method; different letters exhibits a significant variation in traits at $p \leq 0.05$.

4.1.1.4 Phenotypic traits evaluation in all locations

In all location there was a significant variation in phenotypic expression among the tested varieties and test locations at $p \leq 0.05$ level of confidence. These variations were evident in the quantitative traits measured, it was observed the variation in the tested varieties germination percentage varied with means of 65, 79, 81 and 78% recorded in chieftain, landrace, PQH and star 7717 and mean of locations were 75, 74 and 87% in Bomet, Chepkoilel and Ravine respectively **Table 5(a)** and **Table 5(b)** respectively. The number of days to emergence varied among varieties and location at $p \leq 0.05$ with a mean number of days to emergence of 7, 8, 9 and 11days for chieftain, star7717, PQH and landrace **Table 5(a).** Location means 8 days in Chepkoilel and Ravine to 10 days in Bomet Table **5(b).** The number of days to flowering was 50, 55, 74 and 97 days for chieftain, star 7717, PQH and landrace **Table 6(a).** The mean variation with location was 66, 68 and 72 days for Ravine, Chepkiolel and Bomet respectively **Table 5(b).**

The number of days to maturity also varied with variety and location with the mean of 86, 93, 99 and 122 days for chieftain, star 7717, PQH and landrace respectively **Table 5(a).** The variation with location was 97, 99 and 104 days for Ravine, Chepkoilel and Bomet respectively Table 6(b). Total biomass accumulation (TWW) observed was 6.9, 12, 7.2, 8 and 6.9 ton ha^{-1} for the tested varieties chieftain, landrace, PQH and star 7717 **Table 6(a)** while the location means was 8.2, 8.8 and 9 ton ha^{-1} for Bomet, Ravine and Chepkoilel **Table 6(a).** ultimate yields also varied with the means of 4.5, 5.3, 6.5 and 4.7 ton ha^{-1} observed for chieftain, landrace, PQH and star 7717 respectively Table 5(a) while their location means of 4.5, 5.3 and 5.9 ton ha^{-1} was observed in Ravine, Bomet and Chepkoilel **Table 5(b).**

Plant ear heights were 33.1 cm, 107.2 cm, 63.3 cm and 53.3 cm for chieftain, landrace, PQH and Star 7717 respectively Table 5(a). Their mean location ear height was 58.2 cm, 63.5 cm and 71.4 cm in Bomet, Ravine and Chepkoilel respectively **Table 5(b).** Other traits such as the number of leaves at flowering, cob equatorial diameter, length and weight as well as the number of rows and columns also varied significantly among varieties and locations at $p \leq 0.05$. However non-significant genotypes variation with location at $p \leq 0.05$ was observed for these traits germination percentage, ear height and number of leaves at flowering.

In summary the tested varieties varied as follows PQH despite having excellent germination percentage (81%) was late in emergence, flowering and maturity compared to star 7717 and chieftain. It had a medium stalk (1.5- 2m) with an above average ear height and moderate biomass accumulation. Beside it also had a high row and kernel number, long cob, big diameter and high cob weight and subsequently higher yield compared to other tested varieties **Table 5(a).** In the other hand Star 7717 was had excellent germination percentage (79%), fairly early in the number of days to emergence, flowering and maturity compared to PQH and landrace **Table 5(a).** It had a short stalk (<1.5m) with an average ear height and biomass accumulation. High row and column number, long cob with high and moderate in weight. Its yields were higher compared to chieftain but short of PQH and landrace **Table 5(a).**

In spite of it having an excellent germination percentage (79%) landrace was characterized by late emergence, flowering and maturity, compared to chieftain PQH and star 7717. It had a tall stalk height (>2m) and subsequently high ear height, high biomass accumulation compared to other three tested varieties. Besides it had a fewer kernel sets due to lower row and column number. It also had a high cob diameter, shorter length and moderate weight gave rise to low yields compared to PQH **Table 5(a).**

Chieftain had an average germination percentage (65%), early in emergence, flowering and maturity compared to PQH, star 7717 and chieftain. It had a short stalk height (<1.5m) and an ear height (<35cm) and low biomass accumulation. Its kernel sets were high given good row and columns. Smaller cob diameter, enhanced length and weight and subsequently moderate yields however that was still lower than the other tested varieties **Table 5(a).**

Table 5(a): Comparison of means of quantitative traits observed among varieties

Variety	Germ %	DEM	DFLR	DTM	HT FLR	HTM	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Cheiftain	65a	7a	50a	86a	66.6a	99.8a	33.7a	10.4a	6.9a	23.1a	3.8a	14.3a	159.8 a	4.5a
Landrace	79b	11c	97d	122d	124.5 d	243.4 d	107.2 d	13.7c	12c	20a	4.9c	16.9c	190.4 b	5.3b
PQH	81b	9c	74c	99c	103.7 c	171.2 c	63.3c	11.9a	8.8b	30.4b	4.6b	19.1d	222.7 c	6.5c
Star7717	78b	8b	55b	93b	85.9b	131.6 b	53.3b	12b	6.9a	24.9a	3.8a	15.6b	166.9 a	4.7ab
GM	76	9	69b	100	95.2	161.5	64.4	11.8	8.6	25.6	4.3	16.5	185	5.3
SED	1.9	0.1	0.4	1.1	6.2	5.6	4.1	0.2	0.2	1.2	0.1	0.5	12	0.3
LSD	4.1	0.3	0.9	2.4	12.4	11.4	8.3	0.4	0.4	2.9	0.2	1.1	24.3	0.5

Table 5(b): Comparison of means of quantitative traits variation among the location

Variety	Germ%	DEM	DFLR	DTM	HTFLR	HTM	HT ear	LV FLR	TWW ton ha^{-1}	Row	Cob dmt	Cob lgt	Cob wgt	Yield ton ha^{-1}
Bomet	75a	10b	72c	104b	79.5a	154a	58.2a	11.8a	8.2a	26.3b	4.1a	15.9a	180.5a	5.3a
Chepkoilel	74a	8a	68b	99a	94.9b	165.9b	71.4b	11.8b	9b	28.3b	4.5b	18b	201.6b	5.9b
Ravine FTC	78b	8a	66a	97a	111.1c	164.6b	63.5a	10.6a	8.8b	22.3a	4.2a	15.6a	172.8a	4.5a
SED	1.8	0.1	0.4	1.	5.4	4.9	3.9	0.2	0.2	1.3	0.2	0.5	10.3	0.2
LSD	3.5	0.3	0.8	2.1	10.7	9.9	7.9	0.3	0.4	2.5	0.4	0.9	21.	0.4
CV%	4.8	5.1	1.9	3.6	11.3	11.3	5.4	5	8.2	21	10.2	9.7	19.7	11.2

Germination percentage (Germ%), Number of days to emergence (DEM), Number of days to flowering (DFLR), Number of days to maturity (DTM), Height at flowering (HTFLR), Height at maturity (HTM), Height to the ear (HT ear), Number of leaves at flowering (LVFLR), Total wet weight (TWW), Cob diameter (cob dmt), Cob length (cob lgt), Cob weight (cob wgt) and Yield tonnes/ hectare (Yields t/ha).

Means were separated using Fisher LSD method; different letters exhibits a significant variation in traits at $p \leq 0.05$.

4.1.2 Qualitative traits

The expressions of qualitative traits varied significantly among the tested varieties at $p \leq 0.05$ level of confidence **Table 6 (a).** Variation was also evident with location at $p \leq 0.05$ level of confidence. Cob shape varied significantly among the tested varieties varying from chieftain which had an conical cob without taper, conical cob with slight taper in Star 7717, cylindrical with slight taper in PQH and cylindrical with a pronounced taper in landrace while pubescence was observed to vary from dense in landrace, intermediate Star 7717, sparse in chieftain and PQH Table 6 (a) however for these two traits there was no significant variation with test locations **Table 6 (b).**

Kernel colour also varied significantly among the tested varieties ranging from single colour (yellow) in star 7717 and PQH, bi-colour (white and yellow) in chieftain and multi-colour in landrace. The seed texture also varied from smooth, round and regular in landrace, partially rough, irregular and shrunken Star 7717, irregular partially rough and shrivelled in chieftain to irregular reticulate rough and shrivelled PQH **Table 6(a).** It observed that the variation with location was not evident **Table 6(b).**

The cob fill varied significantly among tested varieties ranging from incomplete in landrace to complete in Star 7717, chieftain and PQH. Husk cover protection also varied poor husk cover in Star 7717, good husk cover in Cheiftain and PQH to excellent husk cover in landrace, while snapping ease varied hard in landrace, easy in PQH to very easy in chieftain and Star 77717 respectively **Table 6(a).** Variation with location was not evident at $p \leq 0.05$ level of confidence **Table 6(b).**

Leaf colour intensity varied significantly from light green colour observed in chieftain, intermediate green colour in star 7717 and PQH to dark green colour in landrace Table 6(a) however a significant there was no significant variation with location Table 6(b). A significant variation was evident in tolerance to stress among the tested varieties and test locations.

Cheiftain and star 77717 had a moderate tolerance to stress compared to PQH which had good tolerance to stress and landrace which was poor. The sweetness varied significantly among the tested varieties; landrace was sugary, chieftain was sweet while star 7717 and PQH were very sweet **Table 6(a).**

The results in summary indicate that Star 7717 is a pre-dominantly double cobber with complete cob fill, good husk cover and snaps easily. Cob bears very sweet and soft tender kernels. It also has good seedling vigour, does not lodge and has fair tolerance to stress given Stewarts disease observered in Bomet and crazy top infection observered in Chepkoilel and Ravine respectively. In the other hand PQH is a single cobber with complete cob fill, good husk cover and snaps with ease. Its cobs bear very sweet and soft-brittle kernels. Besides it has excellent seedling vigour, resistant to lodging and good tolerance to stress compared to the other three with limited incidences of crazy top infections Ravine.

Cheiftain was observed to be pre-dominantly a single cobber, with a good husk cover, complete cob fill and snaps very easily. Cob bears sweet, soft and plump kernels. It has good seedling vigour, does not lodge and having fair tolerance to stress limited attacked observed like Stewarts disease observered in Bomet and crazy to infection in, Chepkoilel and Ravine. Landrace was single cobber, with incomplete cob fill and excellent husk cover. Besides it hard to snap and its cob have irregular rows with tough sugary kernels. It also had good seedling vigour, lodges easily and have poor tolerance to stress in most cases is susceptible head smut infection as observed especially in Ravine.

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Table 6(a): Comparison of means of quantitative traits variation among varieties in all location

Variety	CSHP	FILL	HSKC	KNC	LCI	PUB	SNPE	LGR	STXT	VIGOUR	RTS	STN
Cheiftain	3a	3b	5.3a	5b	3a	3a	6.5c	5.3b	3b	5a	5.2b	5.3
Landrace	6.1b	1a	6.7a	7c	6.8c	7c	3.3a	3.4a	1a	6.6a	3.4a	3.2
PQH	5b	2.7b	5.4a	3a	5b	3a	5b	5.7b	5c	6.7b	6.7c	6.8
Star7717	4.2a	3a	4.6a	3a	4.9b	4b	6.7bc	5.1b	3b	5.3a	5b	6.9
Grand mean	4.6	3.2	5.5	4.5	4.9	4.3	5.3	4.9	3	5.9	5.1	5.6
SED	0.3	0.2	0.9	0.1	0.4	0.2	0.5	0.6	0.2	0.7	0.7	0.7
LSD	0.9	0.4	2	0.2	0.2	0.5	1	1.4	0.5	1.6	1.6	1.6

Table: 6(a) Comparison of means of quantitative traits variation among varieties in all location

Location	**CSHP**	**FILL**	**HSKC**	**KNC**	**LCI**	**PUB**	**SNPE**	**LGR**	**STXT**	**VIGOUR**	**RTS**	**STN**
Bomet	4.6a	3.2a	5.5a	4.5a	4.9a	5.3a	4.9a	5a	3a	5.9a	3a	5.9
Chepkoilel	4.6a	3.2a	5.5a	4.5a	4.9a	5.3a	4.9a	5a	3a	5.9a	6.8b	5.9
Ravine FTC	4.6a	3.2a	5.5a	4.5a	4.9a	5.3a	4.9a	5.3a	3a	5.9b	3a	5.9
SED	0.2	0.4	0.8	0.2	0.4	0.2	0.4	0.5	0.3	0.6	0.5	0.7
LSD	0.4	0.8	1.7	0.4	0.9	0.4	0.9	1.2	0.7	1.4	1.2	1.6
CV%	9.2	40.4	30.1	11.2	14.9	10.4	15.8	21.2	9.2	22.8	11.2	9.2

Key: CSHP (cob shape), FILL (cob fill), HSKC (husk cover), KNC (kernel colour), KRN (kernel row number), LCI (leaf colour intensity), NTK (nature of the kernel), PUB (pubescence), SNPE (snapping ease), LGR (lodging resistance), STXT (seed texture), VIGOUR (early seedling vigour) , RTS (tolerance to stress) and STN (sweetness). The means with different letters within a column vary significantly different at p ≤ 0.05

4.2 Genotype, environment and GEI effects

4.2.1 Genotype performance in each location

From the result in Tables 2(a) to Table 4(b) it was observed that the variation among the tested varieties and seasons was evident at $p \leq 0.05$ level of confidence. Quantitative traits measured including the germination percentage, number of days to emergence, flowering and maturity, the height at flowering and maturity varied significantly at $p \leq 0.05$ level of significance. The total biomass accumulation (TWW), yield and yield components such as cob equatorial diameter, length, weight, number of kernel rows and columns also varied significantly at $p \leq 0.05$ level of significance. It was also observed that the means these traits were lower in season two compared to season one in each location.

Qualitative traits also exhibited a significant variation among the tested varieties and season at $p \leq 0.05$ level of significance. These traits cob shape, cob fill, husk cover, kernel colour, leaf colour intensity, pubescence, snapping ease, stand-ability(lodging resistance), seed texture, seedling vigour, tolerance to stress and sweetness Table 6 (a) and Table 6(b). This variation among the tested varieties and season in each specific location indicates a significant influence of the environment on the genotype i.e. genotype x environment interaction (GXE).

Ranking varieties based on their mean yields in each location showed that in Bomet; PQH fared better than landrace, Star 7717 and chieftain in that order. PQH also ranked best in Chepkoilel followed by star 7717, landrace and chieftain. However the order rank changed in Ravine which had highest yield observed in PQH followed by star 7717, landrace and chieftain in that order. Ranking genotypes based on the amount of biomass accumulated also posted similar precedence in each site however the highest values were observed in landrace followed by PQH, star7717 and chieftain in that order.

4.2.2 Genotype performance in all the location

This variation among the tested varieties across the test location was a significant**. Table 5 (a)** and **Table 5 (b)** indicate that the means of the phenotypic traits observed were significant among the varieties and location at $p \leq 0.05$ level of confidence. The quantitative traits measured such as the germination percentage, number of days to emergence, flowering and maturity, the height at flowering and maturity varied significantly at $p \leq 0.05$ level of significance. The total biomass accumulation (TWW), yield and yield components such as cob equatorial diameter, length, weight, number of kernel rows and columns also varied significantly at $p \leq 0.05$ level of significance.

Qualitative traits also exhibited a significant variation among the tested varieties at $p \leq 0.05$ level of significance. These traits cob shape, cob fill, husk cover, kernel colour, leaf colour intensity, pubescence, snapping ease, stand-ability(lodging resistance), seed texture, seedling vigour, tolerance to stress and sweetness had a significant variation among the tested varieties at $p \leq 0.05$ level of significance **Table 6 (a)** however there was no significant variation for the said traits with location **Table 6(b)**.

Genotypic ranking of sweet corn varieties based on their mean yields response in the general environments indicates PQH as the best variety and chieftain variety in three test sites. However ranking varieties their total biomass accumulated the best variety was landrace while Star 7717 and chieftain were the worst performing varieties. Ranking the three environments based on their yield response; Chepkoilel was rated the best compared to Bomet and Ravine.

4.3 Correlation analysis.

Table 7: Correlation of morphological and agronomic traits with yields

DEM							
DFLR	0.8199						
HTFLR	0.2003	0.4734					
HT ear	0.5767	0.7965	0.6481				
HTM	0.6477	0.8741	0.6693	0.8875			
DTM	0.8282	0.9342	0.4518	0.8106	0.8957		
Rows	0.0509	0.0143	0.2517	-0.0846	0.0221	-0.0472	
Cob_lgt	0.2633	0.3140	0.2904	0.1917	0.3356	0.2335	0.6727
Cob_wgt	0.1536	0.2504	0.3707	0.2069	0.2920	0.1746	0.7633
cob_dmt	0.3342	0.5878	0.6119	0.5516	0.6086	0.4546	0.4218
TWW	0.5139	0.8224	0.6746	0.7958	0.8650	0.8064	0.1683
Yields_t_ha	0.1550	0.1958	0.2915	0.1393	0.2353	0.1367	0.7834
	DEM	DFLR	HTFLR	HT ear	HTM	DTM	Rows

Cob_lgt					
Cob_wgt	0.7807				
cob_dmt	0.5701	0.6167			
TWW	0.4001	0.4915	0.7135		
Yields_t_ha	0.7525	0.8844	0.4864	0.3437	
	Cob_lgt	Cob_wgt	cob_dmt	TWW	Yields_t_ha

Yield had a positive correlation with the cob length and weight as well as number of row and columns Table 8. Yields also correlated positively with cob diameter, germination percentage, height at maturity and total biomass (TWW) The cob weight had a high positive correlation with yields/acre, the cob diameter, length, column and row, average correlation days to flowering, germination percentage, height at maturity, height at flowering, TDW and TWW and negative to height at 14,28 and 42 days. Height to the ear have high positive correlation to numbers of days to flowering, maturity and height to maturity, average correlation to cob diameter, days to emergence, germination percentage, height 14 & 42 days and at flowering after emergence and low correlation to cob length, number of column in a cob and height 28 days after emergence.

4.4 Adaptability and yield stability tests.

Plotting the log transformed mean yields of a sweet corn allows for calculation of the regression co-efficient (β= slope graph) of a given variety and the estimation stability of the tested genotype (variety).

Title: The mean yield of sweet corn varieties plotted against location

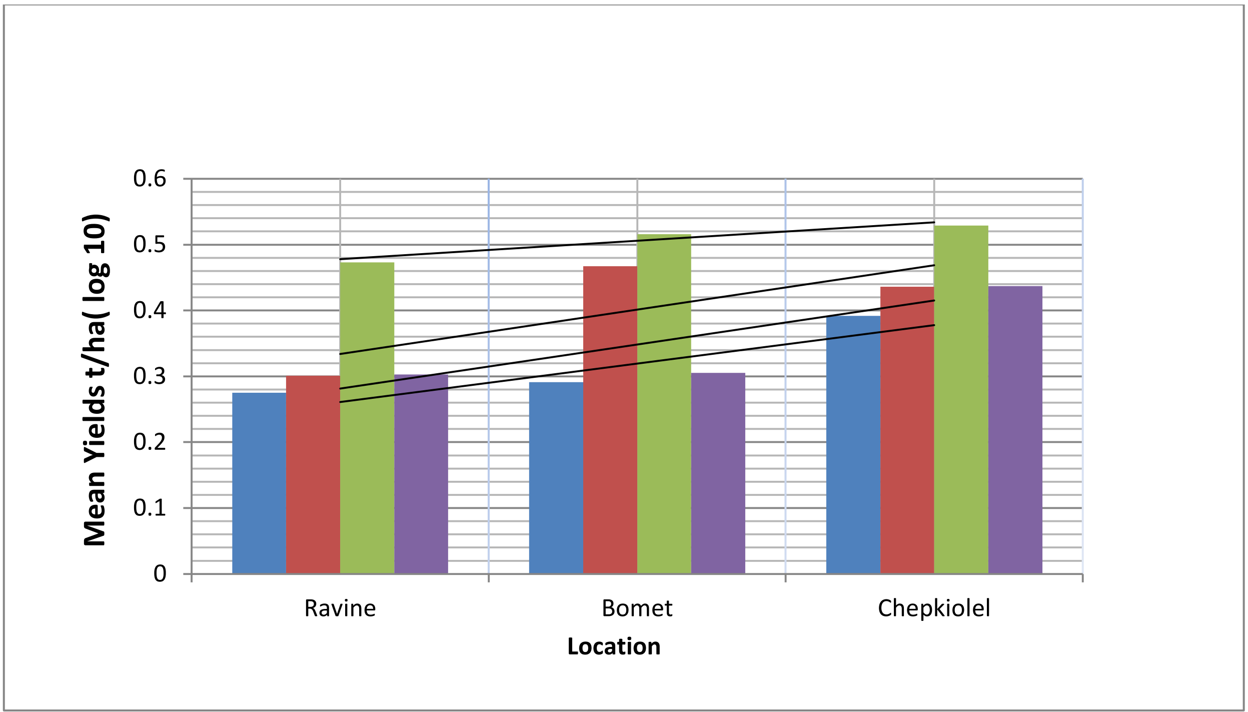

Figure 3: A graph representing variety mean yields of sweet corn varieties against the test location

Figure 3 above indicates the regression values for landrace and star 7717 were 1.29 and 0.04 respectively indicating a below average stability hence specific adaptation whereas chieftain had 0.302 hand slightly average stability but relatively lower yields than PQH that had above average stability couple with higher yields hence the variety was found to be widely adapted.

CHAPTER FIVE

DISCUSSION

5.1. Genotype Characterization

Fisher's Least Significant Difference (LSD) method was used to compare mean qualitative and quantitative characters measured if they differ or not differ significantly at $p \leq 0.05$ level of confidence.

5.1.1 Quantitative traits

It was observed that the number of days to emergence was relatively longer in Bomet and Chepkoilel than Ravine which had advance germination of between 1 to 4 days this was due to slightly higher soil and air temperature in Ravine. In previous studies it has been reported that low soil and air temperature impedes seed germination, early seedling vigour and growth (Öktem *et al*., 2004; Aguyo *et al*., 1997). The number of days to flowering and maturity were also observed to have advanced by between 2 to 4 days in season two. Earlier harvest was realised in Ravine which had sandy clay-loam soil compared to Chepkoilel which had sandy-loam and Bomet with clay-loam soils where the harvest was late. Similar findings were observed in Slovenia (Dragan *et al*., 2008).

High temperature or droughty conditions hastens ear development stage however such conditions during flowering stage interferes with pollination (Yanzhe *et al*., 2007; Nagy, 2007). Poor timing of pollen shed and silk emergence is affected; genotype whose silk emergence and pollen shed are synchronized or exhibits smaller or negative ASI will have a higher harvest index (HI) (Nagy, 2007; Yanzhe *et al*., 2007; Izak & Caligari, 1995). Successful pollination, fertilization and subsequent kernel setting are affected by the silk receptivity and pollen grain vigour (Yanzhe *et al*., 2007). This scenario was the main reason for the low yields realized across the test locations in season two.

Grain yield reduction in some cases is due to poor kernel set ability under field conditions (Viswanatha *et al.,* 2002, Pandey, 2000). In a study that involved two corn hybrids Yedan 12 and Yedan 19. It was observed that silk receptivity, pollen vigour, synchronized silking and pollen release and their effects on the number of kernel sets (Yanzhe *et al.,* 2007). It was also observed that silk receptivity is maintained over a relatively longer period of time after silks emergence however the percentage kernel set and weight decreases with silk aging prior to pollination. This is because pollen grains that shed earlier had higher TTC-dehydrogenase activity hence higher germination percentage, rapid pollen tube growth rate and percentage of kernel sets and kernel weight than those that shed later (Yanzhe *et al*., 2007).

Correlation analysis indicates that the total biomass accumulation had positive correlation to the yields. It was observed that the yields decreased with a decrease in the total biomass; studies have shown that the plants photosynthetic activity decrease with reduction in the canopy size and leaf area hence the reduction plant's capacity to withstand droughty conditions and subsequently low yields (Bertoia *et al.,* 2002; Pandey *et al*., 2000). Drought stress tolerance which occur in cereals where in post-anthesis stress grain filling is dependent partially on actual photosynthesis and the carbohydrates stored during pre-anthesis period are mobilized and translocated from the vegetative parts. However due to low net photosynthesis and limited carbohydrates reserves grain filling is severely curtailed leading to low yields (Viswanatha *et al*., 2002; Pandey *et al*., 2000). A reduction of 22.6 - 26.4% in yields was observed in deficit irrigation treatments due to a decline in the kernel number and weight. Grain yield reduction 37%, 18% and 10% has been attributed to a decline in canopy size, kernel weight and kernel number respectively under water stress condition (Viswanatha *et al*., 2002; Pandey *et al*., 2000; Bray, 1997). Morphological traits expression also been observed to be slowed under deficit irrigation (Pandey *et al*., 2000; Bray, 1997). From the results it was evident that the yields of sweet corn varieties vary with variety, location and season. Such observation was also noted on the earlier optimum yields and quality evaluations (Dragan *et al*., 2008; Marton *et al*., 2007; Nagy, 2007; Öktem *et al*., 2004).

The quality of the growing environment and GXE effect can have synergistic or antagonistic effect on the genotype response and pest/ pathogen prevalence leading to high or low productivity of the genotype(s) tested (Viswanatha *et al*. 2002; Pandey *et al*., 2000).

5.1.2 Qualitative traits

The plants qualitative (morphological) traits are genetically controlled and thus variation is a function of a gene (Fehr, 1987). However they are to a smaller extent influenced by the environment and its interaction (GXE). Environmental condition affects plants both vegetative and reproductive phases (Pandey *et al*., 2000; Bray, 1997). Genotypic variation among tested varieties was evident in their kernel seed colour, cob shape, seed texture, leaf colour intensity, pubescence, stand-ability and husk protection as well as tolerance to stress (Pandey *et al*., 2000; Bray, 1997; Fehr, 1987). It has been observered that plant genotypes vary in the uptake, translocation, accumulation, and utilization of mineral elements (Pandey *et al*., 2000; Ralph, 1983).

The tested varieties had distinct kernel colour ranging from yellow in PQH, golden yellow in star 7717, white and yellow in chieftain and multi-coloured landrace. It's on record that the kernel colour influences the availability, type and amount of phyto-nutrients contained. It has been observed that deep-green to light yellow colour in fruit and vegetables have higher accumulation of anthocyanin content hence rich in vitamins.

(H*ttp:www.omafra.gov.on.ca/English/crops/pub891/14corn/html*).

It has been observed that the best quality ears are obtained by growing sweet corn in cool environments (Boyette *et al*., 1990). Cool temperature slows down the conversion of sugar into starch whereas high temperature hastens (Boyette *et al*., 1990). Quality ears were realized in Chepkoilel and season one. However since quality is subjective the variation among the varieties with location perse cannot be clearly singled out. This is because variations in quality are dependent on the time of harvesting, consumer tastes and preference (Marton *et al*., 2007; Nagy, 2007; Davis 1997).

5.2 Effect of environment on genotype expression

Genotypic traits exhibited a significant variation among the tested sweet corn varieties, seasons and locations (Dragan *et al*., 2008; Marton *et al*., 2007; and Nagy, 2007). It was observed that chieftain was susceptible to Stewart's disease in Bomet compared to Star 7717 which had few incidences of crazy top infection in Ravine and Chepkoilel and landrace that had high infestation of head smut in Ravine and Chepkoilel. The environmental stress affects the crop performance by improving or limiting its potential while enhancing disease/tolerance or susceptibility (creating favourable condition for pathogen or pest attack) (Janick, 2005). It has also been observed that genotypes vary in the ability to absorb, accumulate and utilize essential nutrients Ralph, (1983) the nutrients are essential in improvement of plants tolerance to pest/disease as well as preventing deficiency related diseases.

The evaluation of genotype(s) respond differently to a given set of environment(s) this offers a tool quantitative grading of this environment based on its discriminating or no discriminate ability (Lu'quez *et al*., 2002; Romagosa & Fox, 1993; Jatasare & Paroda, 1980; Eberhart & Russel, 1966;). MET is method of indirect selection used in the selection of superior genotype(s) for yield is based on the mean values in each location or across a number of locations in which the genotype(s) are tested (Lu'quez *et al*., 2002). This element is essential in participatory plant breeding and participatory variety selection in which the development and selection of new crop varieties are based on consumer preference and farmers' interests. Such selections for said traits are done on the farmers' fields.

5.3 Correlation between Yields and other Characters

It has been observed that the measure of stability reduces the correlation between the phenotypic and genotypic means values hence reducing the progress of selection in breeding programs (Comstock & Moll, 1963). It was observed that yields of sweet corn varieties correlate positively with the total biomass and other yield components: cob diameter, length and weight, the number of columns and rows as well as the kernel number. This means the variation in the traits would affect the yields realized in that case; similar sentiments have been reported by other researchers (Viswanatha *et al*., 2002; Pandey *et al*., 2000; Bray, 1997). Germination percentage, ear height, height at flowering, and height at maturity had low correlation with yields an indication of their limited influence on the ultimate yields realized.

5.5 Adaptability and Yield Stability

It was observed that PQH posted the highest mean yields across all locations and had slight magnitude changes compared to the other three varieties which posted impressive yields in one location and poor in the other. Besides the regression co-efficient obtained were β =0.81 PQH compared to β=1.29, β=0.302 and β=0.04 for landrace, chieftain and star 7717 respectively. PQH had high yields across all location with slight magnitudes change in yield compared to landrace, chieftain and star 7717 which had high yield in specific locations often with higher magnitude changes in yields across the locations.

Genotypes are said to be stable and widely adapted if this is coupled with high yields and minimal magnitude changes among locations (Finlay & Wilkinson, 1963). Yield stability eases the selection of genotypes or varieties that are stable in specific environments or across varied environments (Romagosa & Fox, 1993).

In study it was evident that PQH was the most ideal stable with wide adaptation to the three test sites. It also had high yields and excellent taste making it an ideal variety for production compared to Landrace, chieftain and star 7717 were less stable with specific adaptation to each location and higher yields in specific location.

CHAPTER SIX

CONCLUSION AND RECCOMMENDATION

6.1 Conclusion

The quantitative traits expression varied significantly among the tested varieties, locations and seasons while evident variation was observed among the tested varieties for qualitative traits except seedling vigour and tolerance to stress which also varied with location and season. Pacific Queen Hybrid was stable, adapted and high yielding across to the three test locations.

Chieftain, Landrace and Star 7717 were less stable, had low adaptation and high yields in specific location. Yields had a positive correlation with other agronomic traits.

Pacific Queen Hybrid and Star 7717 had very sweet taste while chieftain and landrace were sweet and sugary respectively.

6.2 Recommendation

Pacific Queen Hybrid is an ideal variety suitable for production in all the locations while landrace, Chieftain and star 7717 are suitable for production in Bomet and Ravine respectively.

CHAPTER SEVEN

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APPENDIX

Chieftain at silk stage Landrace

Star 7717 at silk stage PQH at silk stage

(Source: Author, 2013)

Chieftain bicolor

PQH cob

Landrace

Star 7717

(Source: Author, 2013)

Table 8: Site characterization

Location	Longitude	Latitude	Altitude M asl	Precipitation	Temperature	Soil characteristics PH	Textural-class
CUC Farm	35º 15'E	0 º31'N	2180M	1800mm	21ºC	4.98	Sandy loam
Koibatek FTC	35º 37'E	0º 03' S	1800M	1000mm	24 ºC	4.72	Sand-clay loam
Kipsarwet	35º20' 14"E	0º 43' 44" S	1980 M	1500mm	18 ºC	5.83	Clay- loam