EVALUATION OF MEDIUM DURATION PIGEONPEA (*Cajanus Cajan*) GENOTYPES FOR GREEN VEGETABLE PRODUCTION AND ACCEPTABILITY IN MAKUENI COUNTY OF EASTERN KENYA

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DECLARATION

I declare that this is my original work. It is a record of information and data from my own field operations, sensory evaluation, and analyses. This material has never been presented before in any university or academic institution for any academic award.

27/8/15

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DEDICATION

This study could have never been accomplished without the endless support and care from my beloved wife, Eveline, who's, coming into my life, was a blessing, and my children, of whom being a Father made me strive for the best.

This thesis is dedicated to them.

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ABSTRACT

Pigeon pea is an important crop in marginal rainfall, in the arid and semi-arid (ASAL) regions, where it is used as a supplementary source of dietary protein. Previous research has concentrated in identification of genotypes adapted to rain fed condition, for dry grain. Information on the performance of these genotypes for vegetable production, preference by consumers and farmers under irrigated and rain-fed condition is lacking. The aim of this research therefore, was to evaluate and quantify plant growth parameters and yield of twelve medium duration pigeon peas genotypes: ICP 7035B, ICEAP 00068, MTHAWAJUNI, MZ 2/9, KAT 60/8, ICEAP 00540, ICEAP 00557, ICEAP 00911, ICEAP 00902, ICEAP 00554, ICEAP 00850 and KIONZA, at two locations in Eastern region of Kenya, under rain-fed conditions at Kambi Ya Mawe and supplementary irrigation at Kiboko. Days to flowering, plant height, number of primary and secondary branches, grain and pod yield, pods per plant, pod length and width were quantified in experimental plots in randomized complete block design (RCBD) with three replications, at both locations. Preference and acceptability evaluation done by farmers and panelists, was done on six sensory parameters. These were: Seed color, Seed appearance, Seed taste, Seed aroma, Seed texture (mouth and hand feel) or softness and overall acceptability, using Hedonic scale of 1-7 (1-dislike very much and 7-Like very much) at both location for both seasons.

Significant differences (*P<0.01*) in days to 50% and 75% flowering and plant maturity duration respectively, were recorded among pigeonpea genotype at both locations. Plant height differed significantly (*P<0.05*) among genotypes during both main crop and ratoon crop seasons. Supplementary irrigation (SI) recorded a positive increase on all the yield components, except for shelling percent, which was reduced by seven (-7) percent. Plant height, flowering, and maturity periods were enhanced by 105, 30, and 29%, respectively under supplemental irrigation. Similarly, pod length and width were also increased by 6, and 8%, respectively under irrigated conditions. Significant and positive correlation coefficients between grain yield and pods per plant were recorded, indicating that this is an important genotypes selection criterion for vegetable pigeon peas. Genotypes ICEAP 00068, ICEAP 00540, ICEAP 00554, ICEAP 00902, KAT 60/8 and MZ 2/9 were identified for high productivity potential under rain-fed conditions and ICEAP 00902, ICEAP 00068, ICEAP 00557, ICEAP 00554, KAT 60/8 and MTHAWAJUNI under supplementary irrigation. The genotypes KAT 60/8, ICEAP 00068, ICEAP 00554, and ICEAP 00902 were suitable for production under both rain-fed and supplementary irrigation.

Sensory evaluation for preference and acceptance of genotypes at both locations indicated a significant difference among the genotypes on seed appearance, overall Acceptance, seed color, aroma, and cooked seed tenderness, as scored by farmers and panelists. The sensory characteristics of pigeon pea seed were also influenced by genotypes x locations and seasons x locations. The genotypes ICEAP 00068, ICEAP 00540, ICEAP 00554, ICEAP 00902, KAT 60/8 and MZ 2/9 had good favourable scores and preferred by both farmers and panellists under rain-fed and ICEAP 00902, ICEAP 00068, ICEAP 00557, ICEAP 00554, KAT 60.8 and MTHAWAJUNI under supplementary irrigation. The genotypes KAT 60/8, ICEAP 00068, ICEAP 00554, and ICEAP 00902 were suitable for production under both rain-fed and supplementary irrigation. Production of pigeon peas can be greatly enhanced with selective water application. Incorporation of organoleptic properties (seed colour, size, weight, and tenderness) in breeding strategies can optimize the utilization of vegetable pigeon pea genotypes and enhance food security.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND INFORMATION

Pigeonpea is one of the most important pulse crop that performs well in semi-arid tropics (Kimani *et al.,* 1994). These areas suffer from a number of biophysical and socioeconomic constraints, which includes erratic and unpredictable rainfall, harsh thermal regime, land degradation, low level of input use and technology adoption (Bhatia *et al* 2006). Because of its capacity to tolerate drought and ability to utilize the residual moisture during dry season, pigeonpea has an important place in the rain-fed farming system, adopted by millions of smallholder farmers, in low rainfall areas (Mula and Saxena, 2010). Eastern region of Kenya, which is mainly composed of zone IV, V and IV (Omanga and Matata, 1987), is the single most important pigeonpea producing area in Kenya, with principal production Counties being Machakos, Makueni, Kitui, Meru and Embu, accounting for slightly about 99 percent of total national production (Latha *et al.,* 2008). Pigeonpea is ranked the third most important legume in Kenya, in terms of area, after beans (*Phaseolus vulgaries L*) and cowpea (*Vigna unguiculata L.*) (Mergeai *et al.,* 2001a and Jones *et al.,* 2002).

Pigeonpea is a member of the sub-tribe *Cajaninae,* tribe Phaseoleae, and family Leguminosae (Van der Maesen, 1990). It probably evolved in South Asia and appeared around 2,000 BC in West Africa, which is considered a second major center of origin (Van der Maesen, 1980). It was most likely introduced into East Africa from India by immigrants in the 19th century (Van der Maesen, 1980), and is now widely grown in the Indian subcontinent which accounts for almost 90 percent of the world's crop (Nene and Sheila, 1990). Globally, in 2011, pigeonpea was cultivated on 5.8 million ha, out of which, 3.53 Million Ha (61 percent) is confined in India alone. In Africa, Kenya contributed 138,708 Ha, Malawi 190,437 Ha, Uganda 92,565 Ha, Tanzania 288,161 Ha, Democratic Republic of Congo 11,536 and Burundi 3,016 Ha in 2011 (*FAOSTATS*, 2013).

Pigeonpea is mainly grown for food, to supplement the cereals based rural diets which are deficient in protein (Omanga, 1997) as green vegetable peas or dry grain, therefore playing a vital role in food nutrition, security and poverty alleviation (Mula and Saxena, 2010), at household level. Impact assessments in Makueni County has shown that at on-farm level, 68 percent of the fresh vegetables is consumed at household level (Shiferaw *et al.*, 2008), while the rest is sold to the urban market, through non-conventional channels, making it difficult to quantify productivity and volumes sold. When used as a "vegetable", the pea is picked when the seeds have reached physiological maturity, that is, when they are fully grown but just before they lose their green color (Singh *et al.*, 1984). At this stage the green seed is more nutritious than the dry seed because it has more protein, sugar, fat and it will have accumulated most or all of its dry matter, but not completed converting sugars to starch and still somewhat tender (Faris and Singh, 1990).

Vegetable pigeonpea should be early podding, round-the-year green pod production, multiple harvesting of pods, long green pods with least stickiness on their surfaces, fully developed ovules, easy shelling, large attractive white mature seeds and weighing about 15 g 100 when dry (Saxena *et al.*, 2010a), with long shelf life of green pods and shelled grains (Faris *et al.*, 1987). They should be good in appearance, sweet in taste and have desirable organoleptic/sensory properties to fetch a good price in the market (Saxena *et al.*, 2010b).

Initial pigeonpea research in Kenya was concerned with identification of genotypes that have high grain yield potential. As a result, a dozen of improved medium duration pigeonpea genotypes, adapted to Eastern region of Kenya, and meet both household and dry grain market requirements were developed through selection and hybridization. Adoption of these genotypes is evident and consumption is widely practiced both for dry grain as well as green pea as vegetable, in many parts of the Eastern region (Jones *et al.*, 2001; Mula and Saxena, 2010).

The performances of these genotypes for vegetable pigeonpea production in terms of productivity are poorly documented (Silim, 2001). There are also no statistics on the area, production and productivity of vegetable pigeonpeas in Kenya (Silim, 2001). As improved pigeonpea genotypes are developed to overcome challenges of biotic and a biotic to achieve goal for higher yield, consumer preferences of pigeonpea genotypes and products must be considered at an earlier stage in the breeding process (Yueng, 2007). This will ensure that the genotypes being introduced to farmers are accepted based on sensory characteristics. Among the current genotypes being commercialized by farmers in the region for vegetable pigeonpea production, there is limited systematic information on the description of sensory properties that differentiate them in terms of liked, or disliked and also in terms of flavor and texture.

1.2 PROBLEM STATEMENT AND JUSTIFICATION

Kenya is currently facing challenges arising from global phenomena such as global warming and food and financial crises (GOK, 2011). Kenya's Vision 2030 had been adopted as a new blue print for Kenya's development, which emphasizes the enhancement of productivity of crops, incomes, food security, and nutrition, to address these challenges (GOK, 2007). A large proportion of the country, accounting for more than 80 per cent, is semi-arid and arid with an annual rainfall mean of 400 mm. These areas include the greater part of the Eastern region of Kenya, which is classified as Arid and Semi-arid Land (ASAL). Droughts are frequent in these regions, and crops fail in one out of every three seasons is prevalent. Poverty and food insecurity are acute in these regions, with a mean of 75% of the population using less than 2 Dollar per day (Kimani et al 1994). As a major food crop in the region, pigeonpea has the potential to increase income and food security, among the smallholder households in the region.

The main objective of the past research work, has traditionally been on increase of yield and improvement of other production characteristics. Researchers have majorly focused on visible characteristics of raw seeds to determine seed quality. However, visible characteristics are not always reliable indicators of cooking characteristics, which are of great importance to consumers. The success of any newly introduced variety will depend not only on production characteristic, but also on its acceptability to consumers in terms of both sensory and utilization characteristics (Kapinga *et al.*, 2000). Consumers determine the adoption and acceptance of genotypes, and therefore, their preferences, fears, and aspirations have to be taken into consideration before new genotypes are released (Kapinga *et al.*, 2000). Their performance under different conditions such as irrigated and rain fed need to be documented. Even though these genotypes are being harvested for green vegetable, they have not been evaluated for green vegetable productivity and consumer acceptability. This study evaluated twelve (12) genotypes for green vegetable productivity and consumer acceptability in the Eastern region of Kenya.

There is a growing market for fresh vegetable pigeonpeas in Kenya, yet no genotype evaluation for the purpose has been done targeting this market. Information on performance in terms of productivity and acceptance of these genotypes for vegetable pigeonpea is scanty (Silim, 2001). There is need to identify, among these genotypes, those with potential for high vegetable yields and good acceptability to cater for the market. In Eastern Kenya, especially in the county of Makueni, households live below one dollar a day (Shiferaw *et al.* 2008). If the production of marketable pigeonpea green vegetable were expanded, this would increase incomes generated by smallholder farmers and help in alleviation of poverty.

1.3 RESEARCH OBJECTIVES

The Broad objective of this study was to identify vegetable medium duration Pigeonpea genotypes, with high yield potential, adopted to both rain-fed and supplementary irrigation, and are acceptable by smallholder farmers, with the overall goal of addressing the problem of livelihoods in the Eastern region of Kenya.

The specific objectives:

- To evaluate the yields of different genotypes of vegetable medium duration Pigeonpeas under rain-fed and supplementary irrigation in Eastern region of Kenya
- To determine the acceptability of vegetable medium duration Pigeonpea genotypes among the farmers and consumers, using sensory characteristics

1.4 RESEARCH HYPOTHESES

- There are no significant difference in productivity among vegetable pigeonpea genotypes under rain fed and supplementary irrigation
- The genotypes are all acceptable as green pigeonpeas vegetables under rain fed and supplementary irrigation.

CHAPTER TWO: LITERATURE REVIEW

2.1 THE PIGEONPEA

The pigeonpea is a member of the sub-tribe *Cajaninae*, tribe Phaseoleae, and family Leguminosae (Van der Maesen, 1990). It's the only cultivated food crop of *Cajaninae* sub-tribe of the economically important leguminous tribe *Phaseoleae*, which contains many bean species consumed by human beings (Mula *et al.*, 2010). Pigeon pea probably evolved in South Asia and appeared around 2000 BC in West Africa, which is considered a second major center of origin (Van der Maesen, 1980). The crop was most likely introduced into East Africa from India by immigrants in the 19th century (Van der Maesen, 1980). It is now widely grown in the Indian subcontinent which accounts for almost 90 percent of the world's crop (Nene and Sheila, 1990). There is also substantial area of pigeonpea in Kenya, Malawi in Eastern Africa and in the Dominican Republic and Puerto Rico in Central America (Nene and Sheila 1990).

2.2 CLASSIFICATION OF PIGEONPEAS

The plant is classified into the kingdom (Plantae), division (Magnoliophyta), class (Magnoliopsida), order (Fabales), family (Fabaceae), genus (Cajanus), species (C. cajan) and the binomial name is *Cajanus cajanifolius* (Linnaeus) Millspaugh (Mula *et al.*, 2010). Leaves are trifoliate and spirally arranged on the stem. Flowers occur in terminal or axillary racemes, are 2-3 cm long and are usually yellow, but can be flocked or streaked with purple or red. Pods are flat, usually green in color, sometimes hairy, streaked, or colored dark purple, with 2-9 seeds/pod. Seeds are widely variable in color and weigh 4-25g/100. Pigeon peas are majorly classified in two ways, In terms of growth pattern and length of duration to maturity (Troedson *et al.*, 1990). The determinate types have pods in clusters at the top of the canopy and plant growth ceases after the induction of flowering and pod maturity is more or less uniform (Saxena *et al.,* 2010b). These types, however, are more susceptible to pod borer attack, and both *Helicoverpa armigera* (Hübner) and *Maruca testulalis* (Geyer) can cause serious yield losses (Minja *et al.,* 1999 and Reddy, 1990). On the contrary, in-determinate types, the terminal buds are vegetative and the flowers are borne in auxiliary clusters and tolerate biotic and a biotic stresses better than determinate types (Saxena *et al.,* 2010b).

Depending on the length of time taken to reach maturity and its growth characteristics Pigeonpea genotypes can be classified into three major types: (1) the short-duration type that takes 100-120 days to mature and has a determinate growth habit; (2) the medium-duration group taking 150–200 days to mature and having indeterminate growth characteristics, and (3) the long-duration group that takes more than 200 days to mature, with an indeterminate growth habit (Mergeai *et al.*, 2001b, Silim 2001 and Troedson *et al.,* 1990). Most of the local genotypes grown by farmers belong to the medium and long duration types (Silim, 2001, Shiferaw *et al.,* 2008). Local genotypes such as Kionza, are susceptible to fusarium wilt, which in some areas has forced farmers to abandon pigeonpea production altogether (Shiferaw *et al.,* 2005). In recent years, ICRISAT, the Kenya Agricultural Research Institute (KARI), and the University of Nairobi (UoN) have developed and tested a number of short, medium, and long duration improved genotypes (Shiferaw *et al.,* 2008), and adoption rate in the region is projected to be at 20 percent (Saxena *et al.,* 2010a). Research towards solving susceptibility to pest and wilt has resulted in the release of two short-duration types called ICPL 87091 (*KARI Mbaazi I*), Kat 60/8, and one long-duration type called ICEAP 00040 (under the release name *KARI Mbaazi II*) (Silim, 2001). Additional genotypes at various stages of testing by ICRISAT, KEPHIS (Kenya Plant health Inspectorate services) and KARI (Kenya Agriculture

Research Institute) include ICEAP 00068, ICEAP 00554, ICEAP 00557, and ICP 6927 for medium duration and ICEAP 00020 and ICEAP 00053 for long duration (Shiferaw *et al.*, 2008).

2.3 GLOBAL PIGEONPEA PRODUCTION

Globally, in 2011, pigeonpea was cultivated on 5.8 million ha, out of which, 3.53 Million Ha (61 percent) is confined in India alone, as presented in Table 1 below. In Africa, Kenya contributed 138,708 Ha, Malawi 190,437 Ha, Uganda 92,565 Ha, Tanzania 288,161 Ha, Democratic Republic of Congo 11,536 and Burundi 3,016 Ha in 2011 (FAOSTATS, 2013).

Table 1: Area, Production, and Productivity of Pigeonpea in 2011

Country	**Area (Million Ha)**	**Production (Million Tons)**	**Productivity (Kg/ha)**
Tanzania	0.288	0.27	946
Malawi	0.190	0.20	1,027
Kenya	0.139	0.08	608
Uganda	0.093	0.09	1,027
DRC	0.012	0.01	621
Burundi	0.003	0.01	1,056
Myanmar	0.633	0.84	1,323
Nepal	0.017	0.01	808
India	4.420	2.86	647
East Africa	0.713	0.65	912
Africa	0.725	0.66	908
Asia	5.072	3.71	732
World	5.836	4.41	755

Source: FAOSTAT, (2013).

While area under pigeonpea globally has been on an upward trend in the last ten years, from 4.43 million hectares in 2002 to 5.84 million hectares in 2011 (32 percent increase), in Kenya, there have been a 14 percent decrease in area from 0.16 million ha in 2002, to 0.14 million ha in 2011. This could have been as a result of land subdivision as human population increases, competition for land with other high value crops such as sorghum and mango. Diseases and pests have also contributed to reduction in area, as most farmers don't have resources to control pests. There was a 40 percent increase in production globally, from 3.16 million tons in 2002 to 4.41 million tons in 2011 (FAOSTAT, 2013), with significant increase in 2006, 2008 and 2011 (Figure 1). In Kenya, Pigeonpea productivity increased by 7 percent, compared to 13 percent global.

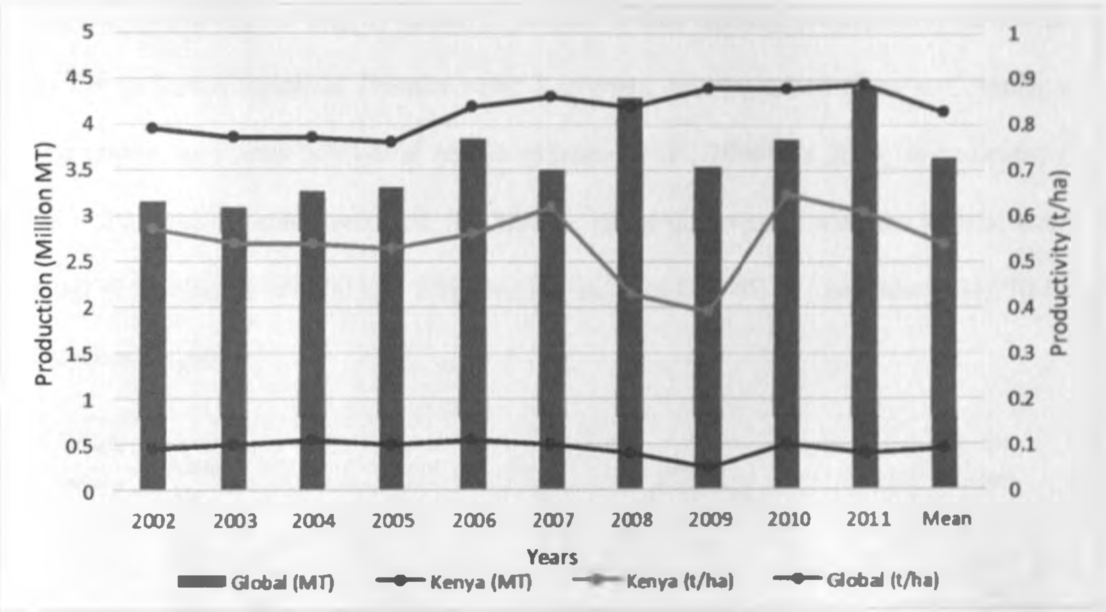
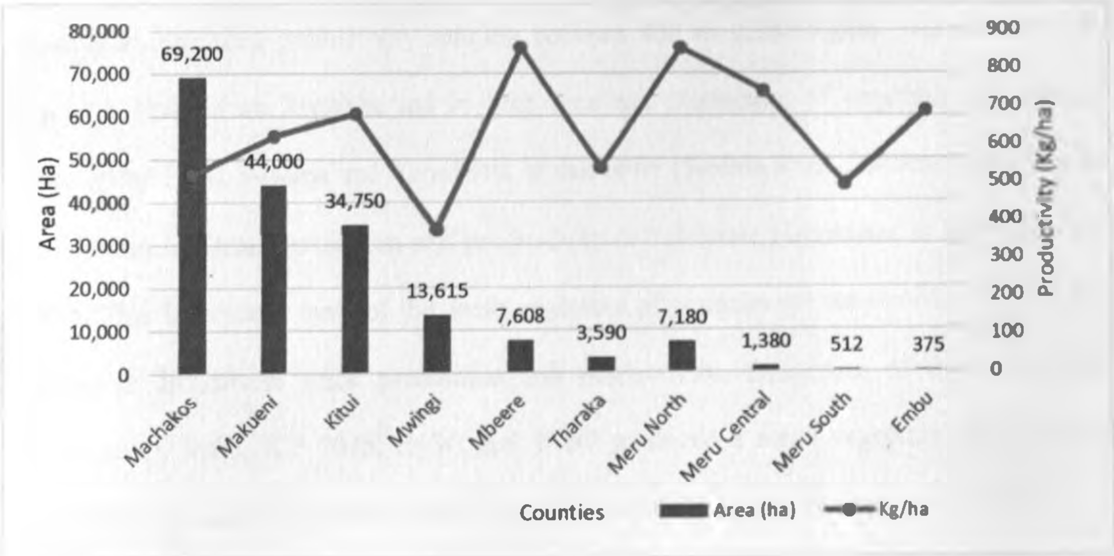


Figure 1: Pigeonpea production (MT) and productivity in Kenya (t/ha) compared to global in 2002-2011

Pigeonpea has not achieved its productivity potential largely due to limited use of appropriate inputs and crop management practices and also the lack of efficient seed system, which hampers adoption of new, higher-yielding genotypes (Jones *et al.*, 2000). The increase in productivity in Kenya has been contributed by introduction of new genotypes, which are high yielding, early maturing, *and fusarium* wilt tolerant and ratoonable. Africa in general, there was a 41 percent increase, in productivity, with Tanzania, Malawi and Burundi recording a significant increase of 67 percent, 46 percent and 31 percent respectively.

2.4 PIGEONPEA PRODUCTION IN KENYA

Pigeonpea is the third most important legume in Kenya, in terms of area, after beans (*Phaseolus vulgaries L*) and cowpea (*Vigna unguiculata L*) (Mergeai *et al.*, 2001a and Jones *et al.*, 2002). Eastern region is the single most important pigeonpea producing area, with principal production Counties being Machakos, Makueni, Kitui, Meru and Embu, as indicated in figure 2, accounting for slightly about 99 percent of total national production (Latha *et al.*, 2008). Other Districts include Tharaka-Nithi, Kirinyaga, Murang'a, and Kiambu Counties in Central region, and parts of Coastal region (Kimani *et al.*, 1994). In 2003, as indicated in figure 3, the Eastern region recorded 183,920 ha, under pigeonpeas, with the highest being recorded in Machakos (69,200 ha), followed by Makueni (44,000 ha) and Kitui (34,750 ha) (Shiferaw *et al*, 2008).



Source: Shiferaw et al. (2008)

Figure 2: Pigeonpeas production in major growing Counties in Kenya in 2003

Pigeonpea is usually planted at the onset of the September/October short rains (Shiferaw *et al.*, 2008) and farmers rarely use fertilizer on the crop, although in some cases they apply manure (Snapp *et al.*, 2003) and weeding is done using hand hoes or oxen-drawn plough. Most of the short and medium duration genotypes are harvested as green/fresh vegetable, usually between February and April (Shiferaw *et al.*, 2008). The long-duration types are, on the other hand, mostly harvested as dry grain in August and September (Omanga and Matata, 1987). Production of pigeonpeas is undertaken wholly by smallholder farmers who cultivate plots ranging from 0.2-1.4 hectares, with the majority of households falling closer to the lower than the upper end (Jones *et al.*, 2002). Some farmers harvest the long-duration types as vegetable pigeonpea, usually during the June/July period (Shiferaw *et al.*, 2008).

2.5 VEGETABLE PIGEONPEAS PRODUCTION

Vegetable Pigeonpea is cultivated commercially for canning in the Dominican Republic, Trinidad, and Puerto Rico. In 2007, reports from eight countries known to produce vegetable pigeonpeas, recorded productivity ranging between 400 to 2,381 Kg/ha. As presented in Figure 4, Dominican Republic led in both area and production of vegetable pigeonpeas, followed by Haiti, Panama and Venezuela in that order (Saxena *et al.*, 2010b). There are no statistics on the area, production and productivity of vegetable pigeonpeas in Kenya (Silim, 2001). This is because most of the fresh vegetable pigeonpeas are consumed at household, making it difficult to track production and productivity. Evaluation of three vegetable genotypes in India, ICP 7035, Hy3C and TTB7 produced a mean vegetable pod yields of 5,232.8 kg/ha, 4,685.4 kg/ha and 904.25 Kg/ha respectively (Rangaswamy, *et al.*, 2005).

2.6 PIGEONPEA PRODUCTION CONSTRAINTS

Farmers' yields in the Eastern regions of Kenya are low, largely due to low rainwater use efficiency as a result of inappropriate soil, water, nutrient and pest management options, lack of seeds of improved cultivars, and poor crop establishment. Dry grain pigeonpea yield varies between 300 and 500 kg ha^{-1} in farmers' fields in Kenya (Kimani *et al.*, 1994; Mbatia and Kimani, 1990), which are far lower than its potential yield under research conditions of 1,500–2,500 Kg/ha (Audi *et al.*, 1996). In a field experiments at Juja and Kabete both in Kenya, yields in sole crop ranged between 2,600 to 4,500 Kg ha^{-1} (Wanderi, 2004) and between 3,780 to 6,300 kg ha^{-1} (Nkonge, 2005) respectively. Statistics on the performance of vegetable pigeonpeas in Kenya is not available, though recent impact assessments in Makueni County has shown that at on-farm level, 68 percent of the fresh vegetables is consumed at household level (Shiferaw *et al.*, 2008), while the rest is sold to the urban market, through non-conventional channels, making it difficult to quantify productivity, productions and volumes sold.

2.6.1 ACCESS TO IMPROVED SEEDS

Although ICRISAT in collaboration with various national programs have developed improved pigeonpea genotypes through participatory variety evaluation, farmers continue to grow traditional genotypes due to ineffective seed distribution channels (Jones *et al.*, 2001). Farmers in Eastern region rely on own seed of the long duration genotypes which are low yielding, fusarium wilt susceptible matures after 9 to 12 months. These are majorly drawn from seed saved from previous harvest (Audi *et al.*, 2009). Availability and access to quality clean planting material can significantly increase production, productivity, and expansion of pigeonpea in the region. Attempts have been made to avail these seed through the formal seed supply system through seed vouchers system, relief seeds in season's preceding drought and developing informal seed systems at village level (Mergeai *et al.*, 2001b).

2.6.2 PRODUCTION SYSTEMS

Traditional African pigeonpea production involves medium and late maturing cultivars either intercropped with cereals (Sakala *et al.*, 2000) or other short duration legumes and vegetables (Atachi and Machi, 2004). Intercropping of Pigeonpeas especially with Sorghum reduces the number of branches, dry grain yield, and weight per plant of Pigeonpeas genotype at harvest, due to competition for light (Egbe and Kalu, 2009), and reduced plant population density (Omanga and Matata, 1987). Intercropping reduces plant population thereby significantly reducing productivity per unit area. As a result of increased demand for vegetable pigeonpeas, many farmers have resorted to monoculture, especially in the irrigation schemes of Kibwezi and Makindu, located in Makueni County. There is need to identify genotypes with high vegetable yield potential and acceptable by consumers, targeting these area. Lack of response to fertilizer application was investigated by Nganyi (2009) and observed that fertilizer treatment don't have any significant influence on the phenol-duration and yield at both KYM and Katumani. In particular, inorganic N fertilizer is deemed unnecessary for the crop since pigeonpea can symbiotically fix about 40-160 kg/ha of N per season (Mapfumo *et al.*, 1999). Pigeonpea is also able to access forms of phosphorus that are normally poorly available in the soil (Ae *et al.*, 1990). This is achieved through the presence of piscidic acid exudates that solubilize phosphorus in the rhizosphere.

2.6.3 PEST AND DISEASES

The widespread practice of intercropping longer-duration pigeonpea genotypes with one or more companion crops may have evolved through farmers' desire to reduce risks of insect losses (Minja *et al.*, 1999). More than 200 species of insects have been found to live and feed on pigeonpea, causing considerable seed damage, ranging from 14 percent to 69 percent, especially in the humid regions (Minja *et al.*, 1999). Due to their prohibitively high costs, subsistence farmers normally use very little or no chemical inputs such as pesticides and fungicides in overcoming pest infestation, leading to reduced yield in terms of quantity and quality (Snapp *et al.*, 2003). Fusarium wilt and sterility mosaic are two major diseases of pigeonpea, of which wilt is of economic importance in East and Southern Africa, causing 30-100 percent yield loss (Reddy *et al.*, 1990). Recent on-farm survey done in Southern and Eastern Africa with farmers observed that 42 percent of them indicated that Fusarium wilt was a major problem (Minja *et al.*, 1999).

2.6.4 PHOTOPERIOD AND TEMPERATURE

Rainfall, photo-thermal, photoperiod, and their associated interactions profoundly control pigeonpea phenological development and productivity (Rao *et al.*, 2002, Silim *et al.*, 2007). Sensitivity of Pigeonpea to temperature and photoperiod are the major constraint to development of stable and predictable management practices, cropping systems, and genotypes (Whiteman *et al.*, 1985). He further indicated that most genotypes are extremely sensitive to variations in climate, particularly in terms of responses of the rates of reproductive development to photoperiod. High temperature affects grain growth and development stage especially after pollination. Heat, higher than tolerance threshold, disrupt physiological actions and make shorter the development stages duration and reduce yield (Osteron *et al.*, 1993).

Photoperiod and temperature strongly affect time to flowering, but not in the same way for all genotypes, suggesting genotypic variation for sensitivity to both photoperiod and temperature (Lannucci *et al.*, 2007). Flowering in pigeonpeas is induced by long periods of darkness (Saxena and Sharma 1990). Plant height, vegetative biomass, and grain yield being the traits most affected (Silim *et al.*, 2006). Photoperiod is positively linked to time to flower and biomass production (Saxena *et al.*, 2010b). Silim *et al.*, (2007) observed that long duration genotypes were the most sensitive, short-duration genotype were insensitive, while extra short-duration genotype were the least sensitive to photoperiod. The development of medium duration genotypes increased the flexibility of pigeonpea cultivation and facilitated its use in different cropping systems. In medium duration pigeonpea, flowering rate responds to a broad temperature range, with optimum occurrence in 18°C to 28°C (Whiteman *et al.*, 1985; Silim *et al.*, 2007). Temperature exerts profound effects on pigeonpea growth, yield and determines the length of growing season of crops by determining the crops germination, vegetative and reproductive stages (Silim *et al.*, 2007).

2.6.5 SOIL MOISTURE CONTENT

Pigeonpeas is one of the most drought-tolerant legumes. It is often the only crop that gives some grain yield during dry spells when other legumes such as field beans will have wilted and perhaps dried up (Okiror, 1986). Pigeonpea roots are thin with a deep-rooting taproot reaching up to 6 feet (2 m) in depth. This deep rooting system helps to improve water infiltration into the soil, which enables it to exploit moisture from deeper soil layers, making it well suited for the drier regions of Kenya (Shiferaw *et al.*, 2008). Pigeonpea is able to maintain vegetative growth during consecutive dry months because of osmotic adjustment and a strong taproot that is established during the first few months of growth (Anderson *et al.*, 2001). Osmotic adjustment increases water absorption, maintain cell turgor, photosynthesis and leaf area duration helps stomatal opening, delay senescence and death in pigeonpeas (Subbarao *et al*, 2001). Traditional long and medium duration pigeonpea landraces have evolved and have apparently adapted to terminal drought stress conditions. Due to climate change, superior genotypes for now and the future should be stable across environments and should be able to withstand effects of climate change (Makelo, 2011). Supplemental irrigation (SI), may be defined as 'the addition of small amounts of water to essentially rain-fed crops during times when rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields'. Mousavi and Shakarami (2010) observed that SI increased seed yield per unit area of chickpeas due to relative reduced water stress during flowering stage, prolonged growth seed filling periods and improvement of 100 seeds weight. Sarintha *et al.*, (2012) observed that moisture stress during early part of growth causes reduced number of pods per plant in pigeonpeas, which may be attributed to flower abortion during main flowering and pod abortion during the period of rapid pod development after flowering. Supplementary irrigation increases plant height, due to prolonging plant growth period, as a result of increased vegetative growth (Oweis *et al.*, 2004b). Pezeshkpour *et al.*, (2008), in the assessment of the single irrigation and the plant density on peas, showed that supplemental irrigation increased seed yield and the biological yield of peas (678 and 303 $kgha^{-1}$ respectively). Late-season moisture stress especially during the grain filling period often prevents starch accumulation in the grain and therefore the test weight of grain declines (Gooding *et al.*, 2003).

2.7 PIGEONPEA YIELD DETERMINANTS

Selection of pigeonpea genotypes, based on grain yield, which is a polygenic character, is usually not very efficient (Saleem *et al.*, 2005). Yield evaluation usually involves the consideration of other characters that determine the overall performance of the genotype (Nwofia, 2012). Yield and its stability depend on the genetic constitution of the genotype and the intensity of the environmental constitutions (Borojevic, 1990). Various methods such as simple correlation, multiple and partial regression analyses, and path coefficient analyses have been employed to determine direct and indirect associations between various morphological characters including grain yield in pigeonpeas (Vijayalakshmi *et al.*, 2013, Udensi and

Ikpeme, 2012, Sodavadiya *et al.*, 2009) and on Black grams (Parveen *et al.*, 2011). Udensi and Ikpeme (2012), showed a positive significant correlation, between yield and number of pods per plant and a negative correlation between yield and days to 50% flowering in Bambara.

2.7.1 PLANT HEIGHT

Plant height in pigeonpea is affected by maturity duration, photoperiod, and environment (Egbe and Vange, 2008). Reddy (1990) observed that late-maturing long-duration genotypes are generally tall, because of their prolonged vegetative phase, while the short duration or early-maturing genotypes are comparatively short in stature due to their short vegetative growth phase. Report by Akinyele and Osekita (2006) showed that height at flowering and final height are vegetative traits that are important for yield determination and therefore, their facilitator role contributes significantly to final yield and should be considered during selection to improve yield in breeding program. Previous studies by Silim *et al.*, (2006), showed that plant height in pigeonpeas is positively correlated to temperature, such that under high temperatures plants are tall and a decrease in temperature results in reduction in plant height.

2.7.2 SEED PER POD

Seed per pod is an indicative of the relative occurrence of abortion at a particular site or season (Thagana *et al.*, 2013). In regions where pigeon pea is used as vegetable, there is strong consumer preference for cultivators with many seeds per pod (Saxena *et al.*, 2010b). The number of seeds per pod depends partially on the cultivar and on the environmental conditions (Cousin, 1997) but has also been documented to be affected by plant density. A progressive and consistent reduction in the number of seeds per pod occurred with increased plant population (Bakry *et al.*, 1984). The mean number of seeds per pod was inversely related to plant population in grain legumes (Ayaz *et al.*, 2004). Most cultivated pigeonpeas have 3–4 seeds per pod (Upadhyaya *et al.*, 2006a). However, there are several genotypes with more seeds per pod (ranging from 5 to 7) in the world collection of pigeonpea germplasm maintained in the gene bank at ICRISAT (Upadhyaya *et al.*, 2006b). Saxena *et al.*, (2010b) reported that a range of 5.4-7.2 seeds per pod was good for vegetable pigeonpeas.

2.7.3 SEED WEIGHT (gms/100 SEEDS)

Seed mass in Pigeonpeas is an important yield component and varies widely in the trait (Reddy, 1990). 100 seeds mass ranges from 2.8 to 22.4g, with majority of genotypes possess a 100 seed mass between 7.0 and 9.5g (Reddy, 1990). Seed size of a plant may vary due to genetics or environmental factors (Hawke, 1989). Large seeds are preferred by dhal consumers partly because with seed size the pericarp percentage reduces, and dhal out-turn increase (Reddy 1990). Studies done by Ong and Monteith (1985) and Manyasa *et al.*, (2008) observed higher 100-seed weight in cooler environments because of a longer seed filling duration.

2.7.4 POD LENGTH AND WIDTH

Long pod size is the most important characteristic of vegetable pigeonpea (Saxena *et al.*, 2010b). In vegetable Cowpeas, pod length and width are important components, as they are known to influence the pod weight and the yield on one hand and governing consumer acceptability of vegetable cowpea and as such a good selection indices in its breeding programs on the other hand (Nwofia, 2012).

2.7.5 BRANCHING

Remanadan (1990) reported a range of 2-66 for primary branches and 0.3-145.3 for secondary branches, among 7,900 pigeonpea germplasm evaluated in India. Branching in plants is generally not essential for their life cycle, but rather serves to enhance vegetative proliferation and to generate multiple locations for seed production (Dun *et al.*, 2006). Excessive branching may be costly with regards to use of resources. Therefore, branching is carefully modulated in response to environmental factors, such as light quality, nitrogen and carbon availability, and growth and development of other plant parts (Dun *et al.*, 2006). Positive associations between yield with plant height, plant spread, and number of primary and secondary branches suggests that spreading, tall, indeterminate pigeonpea types have an advantage in field peas (Walton, 1990). Shorter plants often have a higher number of basal branches than taller plants.

2.7.6 SHELLING PERCENT

Shelling ratio refers to the seed: pod ratio, expressed as a percentage based on mass taken after harvesting with pods and after threshing (Remanadan, 1990). Evaluation done at ICRISAT center, showed that early maturing and late maturing accessions have low shelling ratio compared to medium to mid-late maturing types (Remanadan, 1990). Nganyi, (2009) observed that shelling ratio only varied significantly among the genotypes but was not influenced by site nor fertilizer application at both Kambi ya Mawe and Katumani locations. He concluded that shelling percentage is primarily controlled by the genetic makeup of the genotype and is not affected by the environment or management as suggested by Remanandan, (1990).

2.8 MATURITY INDICES FOR GREEN VEGETABLE PIGEONPEAS

2.8.1 STAGE OF HARVESTING

When used as a “vegetable”, the pea is picked when the seeds have reached physiological maturity, that is, when they are fully grown but just before they lose their green color (Singh *et al.*, 1984). At this stage the green seed is more nutritious than the dry seed because it has more protein, sugar, fat and it will have accumulated most or all of its dry matter, but not completed converting sugars to starch and still somewhat tender (Faris and Singh, 1990).

Determination of the optimum pod age for harvesting, with two commercial vegetable pigeonpea cultivars 'ICP 7035' and 'T 15-15' by Singh *et al.* (1991) found that they differed grossly in their dry matter accumulation rate. When determining the optimum pod growth stage for harvesting of a commercial vegetable pigeonpea crop, the pods for picking are selected visually (Saxena *et al.*, 2010b).

Fully developed, bright green seed is preferred (Faris *et al.*, 1987). Singh *et al.*, (1991) observed that the amount of crude fiber content in the growing seeds increased slowly with maturation and soluble sugars and proteins decreased but the starch content increased rapidly between 24 and 32 days after flowering. Calculation of days from date of flowering can give the correct time for harvesting. The major challenges with harvesting of green pigeonpeas is because of variation in the stage of development of pods even within the same branch (Faris and Singh, 1990). This variation means that pods cannot all be harvested at once, but must be selected as they reach the right stage in order to get the best quantity and highest yield (Mansfield, 1981). Harvesting is commonly done by hand picking, but they may be mechanically harvested for large scale processing such as for canning and freezing (Singh and Jambunathan, 1990), especially with indeterminate types. The high cost of hand harvesting is an important consideration when producing green pigeon pea for market (Singh and Jambunathan, 1990). After the developing pods are harvested in the field; they are shelled to separate the green pigeon peas from their pod walls (Singh and Jambunathan, 1990). The ease with which pigeon pea can be shelled depends on the characteristics of the genotype, and there are large differences in shelling recovery of vegetable pigeon pea (Yadavendra and Patel, 1983). Hand shelling not only requires a low capital investment, also helps produce a much better looking product (Singh and Jambunathan, 1990).

2.8.2 DAYS TO FLOWERING AND MATURITY

Flowering time of a genotype plays an important role in its selection and has a direct relationship with earliness or lateness of a genotype. Upadhyaya *et al.*, (2006a) observed that days to flower were more reliable in arriving at the maturity duration in pigeon pea. Evaluation of materials available at ICRISAT germplasm. Duration to flowering ranged from 55-237 days (Remanadan (1990), from 10,670 observations. Days to 75 percent maturity is difficult character to determine accurately, and is highly influenced by environmental factors such as soil moisture and temperature (Remanadan, 1990).

Genotypes within a maturity class vary in their duration depending on the sowing date, latitude, altitude, the climate and other environmental conditions of a given location (Sharma *et al.*, 1981).Variation in time to flowering results from differences in sensitivity of genotypes to changes in photo-thermal regimes, which affects days to maturity, adaptation and yield in diverse environments (Adams *et al.*, 1985). Temperature is one of the main environmental variables that determine time to flowering (Lannucci *et al.*, 2007). Previous studies by Silim *et al.*, (2006) indicated that for accelerated time to flower and mature, optimum temperature for short-duration genotypes was high (24°C); intermediate (22.5°C) for medium-duration genotypes; and low (18°C) for long duration genotypes. The work of Silim *et al.*, (2006) in addition indicated that greatest delay for time to flower in short-duration genotypes occurred under low temperature and long-duration genotypes exhibited delay under increasing temperature and failed to flower when mean temperature reached 26°C.

2.9 PIGEONPEA UTILIZATION

Pigeonpea is mainly cultivated by smallholder farmers in Eastern Kenya, primarily as a source of food and income (Mergeai *et al.*, 2001b). Due to its multiple uses at household level, pigeonpea is an important crop, consumed as dry grain and as green vegetable. It's widely used as fodder and feed for cattle (Rao *et al.*, 2002). Pigeonpea green manure provides nitrogen-rich organic material to improve soil structure (Whiteman *et al.*, 1985). Rao and Willey (1981) reported that pigeonpea can contribute about 40 kg N/ha through leaf fall and roots. This biological source of N is valuable to smallholder farming systems where resource-poor farmers cannot afford inorganic fertilizers.

Besides its nutritional value; Pigeonpeas also possesses various medicinal properties due to the presence of a number of polyphenols and flavonoids and an integral part of traditional folk medicine in India, China, and some other nations (Saxena *et al*.,. 2010b). In Africa, Asia and South America different parts of the plant are used in the management of disorders such as ulcer, diarrhea, joint pain, cough, sores, dysentery, hepatitis, measles, as a febrifuge, and to stabilize menstrual period (Abbiw, 1990). Green pigeon pea is often compared with green garden peas (*Pisum sativum*) as presented in table 2 below, because in the tropics pigeonpea is often used in place of garden peas, especially in areas with low rainfall, where green peas don't do well. Vegetable pigeonpea sold in the domestic market is either shelled manually before selling to consumers in small volumes or sold in-shell depending on the target retail market (Shiferaw *et al.*, 2008). Pigeonpeas is an ideal supplement to traditional cereal or tuber-based diets of most households, which are generally protein-deficient (Saxena, 2010a). The high nutritive value of the crop is perhaps the most important reason why it should find an important place among the smallholder poor farmers in Eastern region (Odeny, 2007).

Legumes such as pigeonpeas, are commonly used as a substitute for meat, as a source of cheap source of protein and play a significant role in alleviating the protein-energy malnutrition.

Table 2: Comparison of the edible portion of green pea and vegetable pigeonpea on a fresh-weight basis.

Constituents	**Green Peas**	**Vegetable Pigeonpeas**
Chemical composition (g/100 g)		
Edible portion (shelling %)	53.0	72.0
Moisture	72.1	65.1
Protein	7.2	9.8
Carbohydrates	15.9	16.9
Crude Fibre	4.0	6.2
Fat	0.1	1.0
Mineral and trace elements (mg/100 g)		
Calcium	20.0	57.0
Magnesium	43.0	58.0
Copper	0.2	0.4
Iron	1.5	1.1

Source: Gopalan, C., Rama Sastri, B.V., and Balasubramanian, S.C. (1984).

2.9.1 DESIRABLE CHARACTERISTICS OF VEGETABLE PIGEONPEAS

At present a total of 13,632 accessions collected from 76 countries are available for use in breeding programs at ICRISAT (Saxena *et al.,* 2010a). Out of these, 231 were selected and found to have characteristics which are desirable for vegetable production (Saxena *et al.,* 2010a). The mean days to 50 percent flowering ranged from 80 to 229 days, plant height ranged from 85 to 285 cm and pod length, which is an important character for vegetable pigeonpea, varied from 3.2 to 11.6 cm as presented in Table 3. Vegetable pigeonpea should be early podding, round-the-year green pod production, multiple harvesting of pods, long green pods with least stickiness on their surfaces, fully developed ovules, easy shelling, large attractive white mature seeds and weighing about 15 g 100 when dry (Saxena *et al.,* 2010a), with long shelf life of green pods and shelled grains (Faris *et al.,* 1987). They should be good in appearance, sweet in taste and have desirable organoleptic/sensory properties to fetch a good price in the market. Cultivars with bright green seed color are preferred because the cooking water remains clear (Saxena *et al.*, 2010b).

Table 3: Variation of some important agronomic traits within vegetable type Pigeonpeas germplasm from different regions of the world

Region	No. of Accessions	Days to		Plant Height (cm)	Seed Per Pod	Pod Per Plant	Pod Length (cm)
		Flower	Mature				
E. Africa	106	117-229	166-270	130-270	5.4-6.7	26-406	5-12
S. Africa	17	131-194	163-260	185-260	5.4-6.1	33-154	5-11
C. Africa	4	141-166	215-232	200-230	5.4-5.6	74-130	7-9
W. Africa	13	142-156	194-218	170-250	5.4-5.6	67-246	8-10
C. America	26	106-151	167-202	85-240	5.4-7.2	19-160	7-11
S. America	16	132-158	182-230	100-285	5.4-6.1	27-420	5-11
S. Asia	39	80-175	133-235	85-230	5.4-7.2	55-830	3-9
S. E. Asia	8	134-201	190-264	140-210	5.4-5.9	24-119	5-9
Europe	2	156-174	222-237	210-260	5.4-5.8	137	9
Total	231	80-229	133-270	85-285	5.4-7.2	19-830	3-11

Adopted from: Saxena et al., (2010a)

2.10 EVALUATION OF ACCEPTABILITY IN PIGEONPEAS

Sensory evaluation has been defined as a scientific method used to evoke, measure, analyze and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing (Lawless and Heymann, 2010). It's one of the methods used for evaluating product quality and it can be used to describe the sensory properties of a product and determines its acceptability by consumers (Mkanda *et al*, 2007). Human sensory data provide a better model of how consumers will react to food products than instrumental data as human sensory data take into account both the product properties and the interpretation of these properties by consumers (Lawless and Heymann, 2010). Sensory evaluation is easy in its principle but its implementation in the field is often complicated because of low literacy among the rural farmers and difficulty for them to understand some sensory testing methods (Serge, 2001). When the quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic or psychometric. The main objective of breeding programs have traditionally been on increase of yield and improvement of other production characteristics. They have majorly focused on visible characteristics of raw seeds to determine seed quality. However, visible characteristics are not always reliable indicators of cooking characteristics, which are of great importance to consumers. The importance of post-harvest characteristics for the acceptance of new varieties is being increasingly recognized (Kapinga *et al.*, 2000).

Consumers determine the adoption and acceptance of genotypes, and therefore, their preferences, fears, and aspirations have to be taken into consideration before new genotypes are released. The success of any newly introduced variety will depend not only on production characteristic, but also on its acceptability to consumers in terms of both sensory and utilization characteristics (Kapinga *et al.*, 2000). Colored seeds are sometimes favored, while some consumers are attracted to white seeds because they do not tint the color of the cooking water that is often served with the beans (Negri *et al.*, 2001). Visible characteristics of raw seeds, however, are not a reliable measure for cooking quality (Negri *et al.*, 2001). Legumes with similar appearance may have significantly different cooking properties.

2.10.1 METHODS OF SENSORY EVALUATION

The methods used in sensory evaluation can be divided into three categories: discriminative, descriptive, and hedonic tests (Valentin *et al.*, 2012). Discriminative tests are used to evaluate whether any difference exists between two products. Descriptive sensory evaluation identifies, describe, and quantify the sensory attributes of a food material or product using human subjects (Einstein, 1991). The descriptive or hedonic sensory panel comprises of 8-12 people, trained to consistently and reliably identify and quantify individual sensory characteristics of a particular product (Mkanda *et al*, 2007). It aims at understanding product characteristics such as taste, texture, smell, and appearance in a controlled environment (Einstein, 1991). Hedonic tests are usually used towards the end of the formulation process to evaluate which formulation is preferred in product development. The most popular one is the so-called 9-point hedonic scale. Hedonic rating relates to pleasurable or unpleasant experiences. Hedonic rating test is used to measure acceptability of food production. One challenge of using descriptive sensory evaluation is in the use of human subjects, who might be affected by various forms of setbacks such as emotions, social and physical condition, during evaluation of samples, in which such conditions can have a negative impact on the results (Mkanda *et al*, 2007).

2.10.2 FACTORS INFLUENCING SENSORY CHARACTERISTICS

Food choice, like any complex human behavior, is influenced by many interrelated factors (Prescott, 2002). Rozin (2000) argued that culture provides the strongest determinant. To some extent, the effects of culture reflect different dietary histories, determine which foods are acceptable in terms of sensory properties, and create culturally specific flavor principles (Prescott, 2002). Growing location has been reported to affect the cooking quality of legumes by changing their structure. In a study by Iliadis (2003), long cooking lentil varieties significantly differed in their cooking times when grown in different soil types, while short cooking varieties did not significantly differ. He concluded that genotype affected cooking time variations more than environmental conditions. Iliadis (2003) also reported that varieties grown in different climates showed shorter cooking times in the climate that received higher rainfall. Climate, soil type, moisture, and other factors interact with genetic factors to produce cowpeas of varying cooking quality.

When food is in the mouth, taste is perceived when water soluble chemicals within the food dissolves in saliva and interact with taste receptors of the tongue and mouth (Mkanda, *et al* 2007). Components of flavor typically involve taste, mouth-feel, and aroma (Taylor and Roberts 2004). Chewing allows for the transport of aroma compounds from the food to the gas phase in the mouth and then to the nose (Dunphy *et al.*, 2006). Although the intensity of an aroma cannot give a false impression of flavor when flavor is absent (Stevenson *et al.*, 1999), aroma intensity can enhance or suppress taste intensity (Prescott, 1999). The term cook ability of legume seeds refers to the condition by which they achieve a degree of tenderness during cooking, which is acceptable to consumers (Sharma *et al.*, 2011). Cooking generally inactivates heat sensitive anti-nutritive factors such as trypsin and chymotrypsin inhibitors and volatile compounds (Sharma *et al.*, 2011). Legumes change their color during cooking due to solubilization of color pigments (Mkanda, 2007). Sensory panelists give high ratings to cooked seeds with good appearance, taste, and mouth feel (Negri *et al.*, 2001). Color is one of the most important physical attribute that greatly influences consumer perception and can summarily lead to rejection of a product (Pedreschi *et al.*, 2007).

Consumers tend to associate color with sensory and physicochemical attributes of products because they correlate (Pedreschi *et al.*, 2007). Bressani and Elias (1980) reported that dark colored legume seed, that's bronze/brown/speckled may have a higher content of phenolic compounds and concluded that most consumers' prefer light colored bean seeds compared to dark colored seed. Sweetness of the seed is also a preferred character. Normal sugar levels are around 5.0 percent; but researchers at ICRISAT have identified genotypes, such as ICP 7035, with a sugar content as high as 8.8 percent. Phenolic compounds in the seed coat such as condensed tannins, may contribute a bitter taste after cooking in beans (Guzman-Madondo *et* *al.,* 1996). Sharma *et al* (2011) studied the effect of pod color on important organoleptic/Sensory properties of vegetable pigeonpea, and found that fresh seeds harvested from purple pods had poor texture, flavor, and taste as compared to those of green seeds; but after cooking operation, such differences disappeared. This showed that qualitative characteristics such as pod color do not play any important role in determining the organoleptic qualities of vegetable pigeonpea.

As improved pigeonpea genotypes are developed to overcome challenges of biotic and a biotic to achieve goal for higher yield, consumer preferences of pigeonpea genotypes and products must be considered at an earlier stage in the breeding process (Yueng, 2007). This will ensure that the genotypes being introduced to farmers are accepted based on sensory characteristics. There is limited systematic information on the description of sensory properties that differentiate fresh vegetable pigeonpea genotypes currently being commercialized by farmers in Eastern region of Kenya, in terms of liked, or disliked based on color, aroma, tenderness, overall acceptance, flavor, and texture.

CHAPTER THREE: PERFORMANCE OF VEGETABLE PIGEONPEA GENOTYPES UNDER RAIN FED AND SUPPLEMENTARY IRRIGATION

3.1 INTRODUCTION

Pigeonpea (*Cajanus Cajan)*, is one of the most important pulse crop that performs well in semi-arid tropics (Kimani *et al.,* 1994), and is widely grown in the region. Pigeonpea is a member of the sub-tribe *Cajaninae,* tribe Phaseoleae, and family Leguminosae (Van der Maesen, 1990). It probably evolved in South Asia and appeared around 2,000 BC in West Africa, which is considered a second major center of origin (Van der Maesen, 1980). It was most likely introduced into East Africa from India by immigrants in the 19th century (Van der Maesen, 1980). It is now widely grown in the Indian subcontinent which accounts for almost 90 percent of the world's crop (Nene and Sheila, 1990). There is also substantial area of pigeonpea in Kenya, Malawi in Eastern Africa and in the Dominican Republic and Puerto Rico in Central America (Nene and Sheila 1990).

In Kenya, Pigeonpeas grows in areas between latitudes 30°S and 30°N, where moisture availability is unreliable or inadequate and less than 1,000mm annually (Okoko *et al.*, 2002). Traditional African pigeonpea production involves medium and late maturing cultivars, intercropped with either cereals (Sakala *et al.*, 2000; Monaco, 2006), early maturing legumes such as beans, cowpeas and green grams (Mwang'ombe *et al.*, 1998) or with fruit trees (Makelo, 2013). Pigeonpeas is mainly grown for food, to supplement the cereals based rural diets which are deficient in protein (Omanga, 1997). It is mainly eaten green as vegetable in Africa, unlike in India, where dry dehulled split-pea (dhal) is most popular (Mula and Saxena, 2010). A dozen of improved medium duration pigeonpea genotypes, adapted to Eastern region of Kenya, and meet both household and dry grain market requirements have been developed in Kenya, in the past twenty years, by International Crop Research Institute for the semi-arid tropics (ICRISAT) in collaboration with Kenya Agricultural and Livestock Research Organization (KALRO) and University of Nairobi (UoN) (Kimani *et al.*, 2001). Adoption of these genotypes is evident and consumption is widely practiced both for dry grain as well as green pea as vegetable, in many parts of the Eastern region (Jones *et al.*, 2001; Mula and Saxena, 2010). The performances of these genotypes for vegetable pigeonpea production in terms of productivity are poorly documented (Silim, 2001). Concerted effort to identify, among these genotypes, those with potential for high vegetable pigeonpea yields, acceptable by farmers and consumers, has not been done, leaving farmers to harvest vegetable pigeonpeas from genotypes initially selected for grain production. The overall goal of this study was to identify vegetable pigeonpea genotypes, with potential for high yield and acceptable by both farmers and consumers, addressing the problem of livelihoods in the Eastern region of Kenya. The specific objective was to evaluate the vegetable yield potential of different medium duration vegetable pigeonpea genotypes under rain-fed and supplementary irrigation in Eastern region of Kenya

3.2 MATERIALS AND METHODS

3.2.1 STUDY SITES

The study was carried out at the Kenya Agricultural and Livestock Research Organization's Kiboko station and Kambi Ya Mawe (KYM) sub-station between October 2012 and August 2013, under supplementary irrigation and rain fed field experiments, respectively. The two study sites are located in Makueni County. The characteristics of two locations are presented in table 4 below. Makueni County is located in the lower part of Eastern Province of Kenya (Kimani *et al.,* 1994). The two locations experience high temperatures during the months of

January, February, and March, with a mean temperature of 26°C at Kiboko, and 25°C. Both locations experience low temperatures in the months of June, July and August with Kiboko recording a mean of 21.6°C and Kambi ya Mawe 22.5°C.

Table 4: Physical and meteorological characteristics of Kambi ya Mawe and Kiboko Sites

Site	Latitude and Longitude		Altitude	Annual Rainfall (mm)	Mean annual Temperature Max °C	Min °C	Mean °C
KYM	1°57'S	37°40'E	1,250	550	28	17	23
Kiboko	2° 10'S	34°40'E,	975	561	33	14	24

Source: Michieka and Van der Pouw (1977); KYM: Kambi ya Mawe

Kiboko (KIB) research station is located in Makindu Sub-County, in Makueni County. The station is situated 2° 10'S and 34°40'E, 975m above sea level, 156 Km from Nairobi, along the Mombasa highway and under eco-climatic zone V (Michieka and van der Pouw 1977). The soils are well drained, very deep, dark reddish brown to dark red, friable sandy clay to clay (Acri-Rhodic Ferrassols) developed from undifferentiated basement system rocks, predominantly banded gneisses (CYMMIT, 2013). It receives a mean annual rainfall of 561 mm, characterized by bimodal distribution with peaks in April and November. The Centre records a 33°C mean maxima and 14°C mean minima temperatures, with a mean of 24°C. For experiment conducted here, the rainfall was supplemented with irrigation. Kambi ya Mawe (KYM) is a sub-station of KALRO-Katumani, located in Makueni Sub-County, 15Km from Wote town, along Wote-Makindu road, at elevation 1,250 m above sea level, latitude 1°57'S and longitude 37°40'E. The station has been used by several researchers to test genotypes under rain fed condition, to simulate the farmer's condition. The soils are very deep, dark brown in color, and consist of friable sandy clay loam to sandy clay (Siderius and Muchena, 1977), with low organic carbon contents (0.5 – 1.0%) and a slight acid reaction (pH 5.7–6.9 in water). It has mean annual temperatures of 21- 23°C and mean annual rainfall 500–600 mm. The trial here was purely under rain fed condition. The daily maximum and minimum temperature in °C, were collected on daily basis at both locations. Mean daily temperature was obtained by summing the minimum and maximum air temperature on daily basis, then getting the mean, at different phases of growth following method described by (Silim *et al.*, 2007). The growth phases were:

- **Pre-flowering Phase:** Mean temperature from sowing to the date when 50 percent of the plants in a given plot have at least one open flower.
- **Flowering Phase:** Mean temperature from the date when 50 percent of the plants in a given plot have at least one open flower, when 75 percent of pods are mature.
- **Podding Phase:** Mean temperature from the date of 75 percent maturity, to the date last harvest was done, per plot.

3.3 PIGEONPEA GENOTYPE

Twelve medium duration pigeonpea genotypes (ICP (ICRISAT Pigeonpea Program) 7035B, ICEAP (ICRISAT East Africa Pigeonpea Program) 00068, MTHAWAJUNI, MZ (Mozambique) 2/9, KAT (Katumani) 60/8, ICEAP 00540, ICEAP 00557, ICEAP 00911, ICEAP 00902, ICEAP 00554, ICEAP 00850 and KIONZA) were used in this study. KIONZA, a local genotype, being grown by many farmers in the County, for both grain and green vegetable seed, due to its earliness, was used as control in this study. The genotype is an early maturing, mostly takes 120-220 days to flower, depending on the location. Flowers in May, and pods in June/July months, making it the best local genotype for the green pea, compared to others such as Mukune, Katheka and Mwiyumbi, which produces fresh pods in late July/August. The name is derived from the seven seed characteristic.

3.4 EXPERIMENTAL DESIGN

Randomized complete Block design (RCBD) was used in this study, replicated three times at Kiboko and Kambi ya Mawe locations. The experimental units (plots) measured 4 m by 4.8 m in size, 4 rows per plot, with spacing of 1.2m x 0.3m, giving a plant population of 27,760 plants per hectare. The treatments were locations and genotypes.

3.5 AGRONOMIC PRACTICES AND MANAGEMENT

The experimental fields were ploughed and harrowed using a tractor. The seeds were then sown in furrows prepared with hand hoes, at a depth of 10cm at Kambi ya Mawe, on October 21st (dry planting), with the first rain received on 3rd November 2012, effectively being the planting date. At Kiboko planting was done on October, 20th, at the same depth as Kambi ya Mawe, with overhead irrigation done on the same day, effectively being the planting date at this location. The seed were drilled along the furrow, and later thinned to one per hill, two weeks after germination, to a spacing of 30cm. Fields were maintained weed-free using hand hoe, which was done as need arose. At Kambi ya Mawe, weeding was done six (6) times, while at Kiboko, it was done eight (8) times, due to supplementary irrigation, which increased the frequency of germination and growth of weed.

During each season, no chemical fertilizers were applied on the crop, which was consistent with agronomic practices reported by Silim *et al.,* (2006) and Nganyi (2009). The crop was protected from pests such as termites, pod borers, pod suckers, and pod flies by applying pesticides. The effect of termites (*Odontotermes spp* and *Microtermes spp*) was prevalent during the dry months of January and February 2013, mainly at KYM site. They were controlled using Confidor, a termicide, whose active ingredients are nitro-guanidine and chlorpyrifos. Thirty milliliters of Confidor was mixed in 20 litres of water and applied to cover the area being applied uniformly, twice a month, for the two months. Pod Suckers and Pod fly, the major pigeonpea pests in the region (Minja *et al.*, 1999), were controlled by application of broad-spectrum non-systemic, pyrethroid alpha-cypermethrine and dimethoate, a systemic organophosphate. Cypermethrine was mixed and applied at rate of 1.25 litres ha^{-1} equivalent to 25 ml in 20 litres of water. While 35 ml of dimethoate, was applied at the rate of 1,000 litres ha^{-1}. That's equivalent to 35 ml in 20 litres of water. All these pesticides were applied uniformly, interchangeably, using 20 litre knapsack sprayer, when appropriate, 6 (six times) at Kiboko (4 at crop and 2 Ratoon Crop), and seven (7) times, at Kambi ya Mawe (5 at Crop and 2 at Ratoon Crop). Need for spraying was determined by assessing insect presence and damage, through field scouting on weekly basis. Supplementary irrigation was done at Kiboko. Frequency of application depended on the weather condition and rainfall pattern. In total, genotypes received extra 300 mm of water applied (196mm during crop and 104mm during Ratoon Crop) at Kiboko.

3.6 YIELD AND YIELD COMPONENTS

Fourteen (14) yield variables were recorded during the crop (October 2012-March 2013) and ratoon (April-August 2013) seasons, based on the guideline outlined in descriptors for pigeonpea (*Cajanus cajan*) (IBPGR and ICRISAT, 1993).They were: Days to 50% flowering (DAF), Days to 75% Mature (DTM), Seed per pod, Final plant stand (Number), 100 Fresh seed weight (grams), Pod + Grain weight (grams), Threshed grain weight (grams), Pod length and width (cm), pods per plant at harvest, Number of primary and secondary and plant height (cm) and shelling percent.

Days to 50 percent flowering (Days): This was recorded as the number of days from the effective date of sowing to the date when 50 percent of the plants in a given plot have at least one open flower (Remanadan, 1990).

Days to 75 percent Maturity (Days): This was recorded as number of days taken from date of sowing to the date when about 75 percent of the pods are mature. Physical look, pressing of a sample pod within the plots, was also used to determine maturity.

Seed per pod (Number): Seed per pod were counted in three pods per plant and five plants per plot, and mean to give plot mean.

Final plant stand (Number): Final plant stand was taken at final harvest date, by counting the number of plants harvested. The plants counted were within the harvestable area, which comprised three mid rows, of which first plants at the start of each raw was left out, as boarder plants.

100 Fresh seed weight (grams): 100 seed weight in grams was taken at harvest and after threshing of the pods. 100 seed were physically counted per plot, by a team of experienced casuals at both locations and weighed to give the weight per plot in grams.

Pod + Grain and Grain weight (grams): At maturity, the pods from each plot were manually harvested and packed in labeled gunny bags. The weight of pods, with grains before threshing, were weighed, and recorded as Pod + Grain. After weighing, the pods were subsequently threshed and the grains weighed in grams using a digital scale, for grain weight.

Pod length and width (cm): Pod width, (the mid-pod distance in centimeters, from one side to the other), and length, (the distance in centimeters from the tip of the pod to the petiole), were taken from three pods per plant, and five plants per plot, at both crop and Ratoon Crops and locations. This was taken at 75% pod maturity. The Measurement per plants were mean and then used to get the plot mean.

Pods per plant at harvest (Number): Pods per plant was done by counting the total number of pods, ready for harvesting at every time, harvesting was being done. This was done on five plants per plot and getting the mean for the plot tally.

Plant height at maturity (cm): Final plant height was taken, at final harvest, during the crop and Ratoon Crop. The distance from the tip of the plant in centimeters, to the soil surface, of five plants per plot, was taken, using a 200cm long graduated ruler, and mean to give the plot tally.

Shelling Ratio (%): After taking the weight of pods and grain (before threshing) and the grain after threshing, shelling percent was calculated by dividing threshed seed by the Pod plus grain weight, multiplied by 100.

Primary and secondary Branches (Number): The number of primary and secondary branches was counted manually, at both locations, at crop and Ratoon Crops. Five (5) plants per plot were counted for both characteristics, and mean for the plot tally. The branches were counted at 75% pod maturity.

3.7 METEOROLOGICAL DATA

The daily weather data were obtained from the nearby weather stations, located at the respective locations. At Kiboko, the meteorological station was about 200m away from the trial site, while at Kampi ya Mawe the meteorological station was about 500m away from the trail site. The weather data collected included daily rainfall, Maximum and Minimum daily temperature. These were summarized and presented graphically, as presented in Figure 3 and tabulated, as presented in Table 5.

3.8 DATA ANALYSIS

The data collected during the study were analyzed using GENSTAT 14th edition statistical program (Payne *et al.*, 2011). General Linear Model (GLM) for the analysis of variance (ANOVA) was done for each location separately and combined across locations and seasons, following procedures outlined by Gomez and Gomez, (1984). The significant mean values of the genotypes of each parameter were further compared by using the least significant difference (LSD) test at 5% level of probability, using Turkey's method (Ott, 1988). Correlation analysis between yield and yield components was conducted

3.9 RESULTS AND DISCUSSION

3.9.1 WEATHER

The Monthly rainfall and daily temperature for both Kiboko and Kambi ya Mawe locations, are presented in Figure 3 and Table 5. Bimodal rainfall was realized at both locations, with the short rains between October 2012 and March 2013 and long rains between April and August, 2013. Kiboko received a total of 532mm of rainfall (215mm during the short rains and 317mm during the long rains). Highest rainfall was received in the month of December, 2012 (108.4mm) and April (278mm). Compared to the 2011/12 season, the amount of rainfall were higher by 38 percent (21.5mm) during the short rains and 47 percent (102mm) during the long rain seasons. Compared to the long term means (LTM), the rains at Kiboko reduced by 73 percent (156mm) during the short rains, but increased by 178 percent in the long rains as presented in table 5. KYM received a total of 715 mm of rainfall (592mm during the short rains and 123.3mm during the long rains). The long rains in 2012/13 season, reduced by 380 percent (468.7mm), compared to the short rains. Compared to the 2011/12 season, the amount of rainfall were higher by 42 percent (176mm) during the short rains but depressed by 51 percent (128.4mm) during the long rain seasons. Compared to the long term mean of six years, the rains were enhanced by 80 percent (264mm) during the short rains and 12 percent (13.3mm) during the long rains. High rainfall was received in the month of December (207.2mm), March (125mm) and April (112mm). Long term mean temperatures, in the last 6 years, have indicated that mean temperatures at KYM has reduced by 1°C, from 24°C in 2007 to 23°C in 2012, while at Kiboko, temperatures have has remained rather constant at 24°C over the same period, as presented in Table 5.

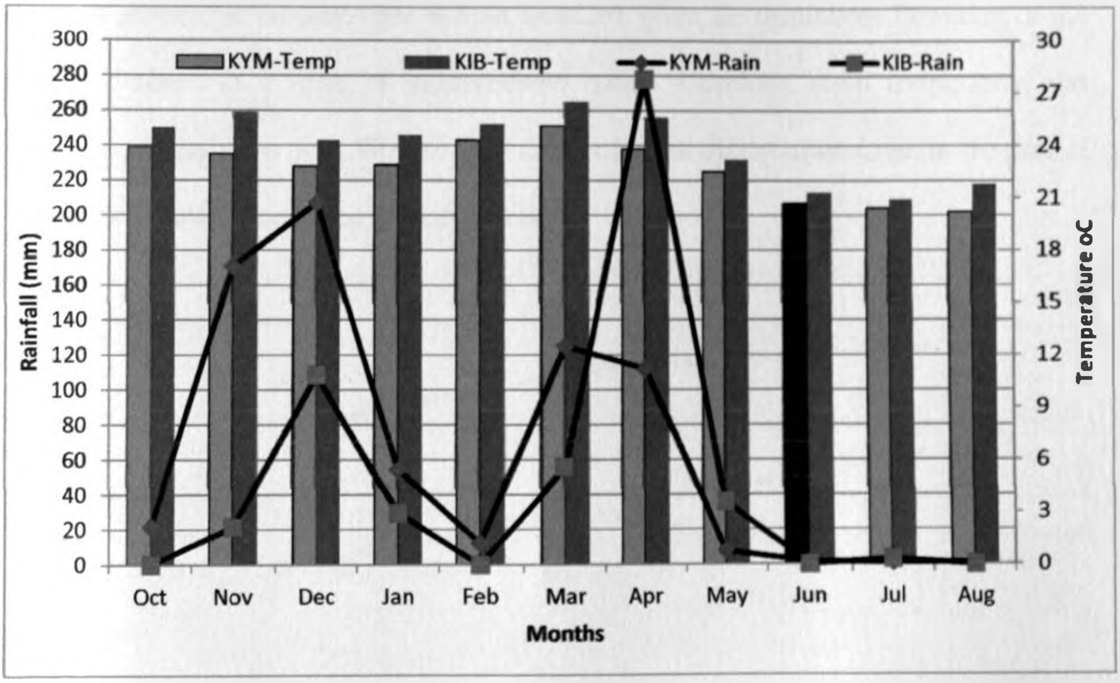


Figure 3: Variation in Rainfall (mm) and Daily temperature (°C) at Kambi ya Mawe and Kiboko location in 2012/13

3.9.2 RELATIONSHIP BETWEEN TEMPERATURE AND YIELD VARIABLES

Mean temperatures experienced at both locations and seasons, indicated that the genotypes were exposed to different temperatures during vegetative, Flowering and pod development phases. The mean temperature at different growth phases was determined and presented in

Figure 4. Kiboko experienced higher mean temperature compared to Kambi ya Mawe. At Kambi ya Mawe, the Pre-flowering phase had a lower mean temperature of 23°C, compared to Kiboko of 25°C. At flowering phase, Kambi ya Mawe recorded 24°C, while Kiboko 25°C. During the Podding phase, Kambi ya Mawe recorded 25°C, while Kiboko recorded 26°C. In general, Kambi ya Mawe experienced a lower mean temperatures of 24°C during the growth phases, compared to Kiboko of 25°C. During the Ratoon Crop, both locations experienced the same mean temperature of 23°C. During the Ratoon Crop, it was difficult to delineate the phases of growth for the genotypes at both locations, given the continuous flowering of the medium duration as a result of indeterminate nature. Therefore, mean temperature was calculated per genotype, from the date after the last harvest during Main Crop, to the date of last harvest during Ratoon Crop, at both locations.

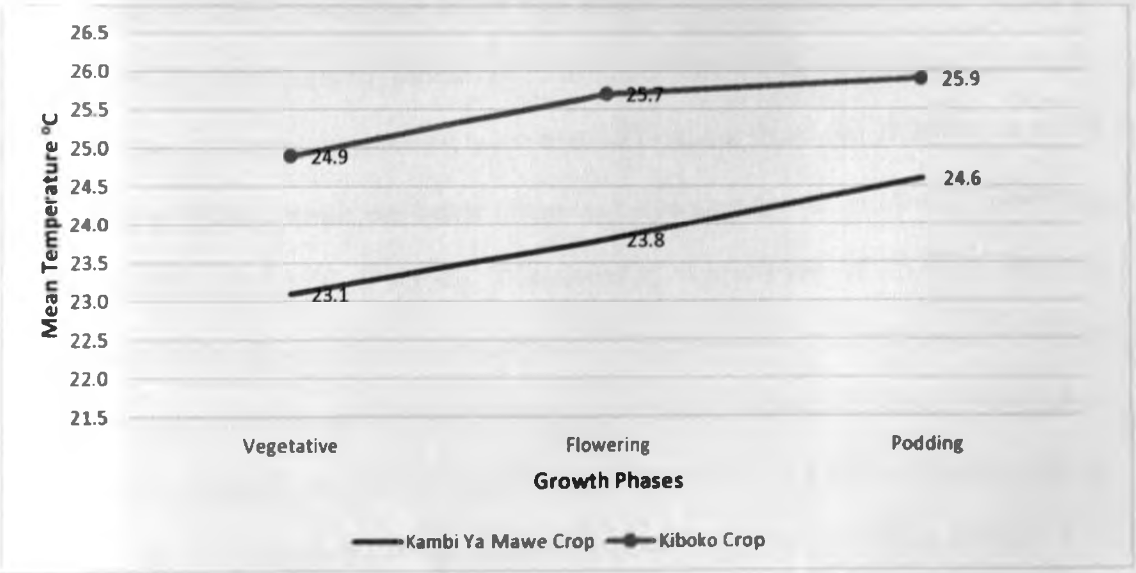


Figure 4: Mean Temperature Variation during growth phases in 2012/13

The overall mean temperature at Kiboko was 24°C, with the mean temperature of 25°C, during the short rains, but reduced by 1°C, during the long rains (24°C). Compared to the

2011/12 season and 10 years long term mean, temperatures at this station has remained constant during long (23°C) and short (25°C) rains. The warmest months at Kiboko were in November, 2012, April, 2013 and March, 2013, while the coolest months were June, July and August, 2013, as presented in table 5. The overall mean temperature at Kambi ya Mawe was 23°C, 1°C below the mean temperature at Kiboko. The mean temperature during the short rains was 24°C but reduced to 23°C during the long rains. The warmest months at Kambi ya Mawe were October, November in 2012 and February, March and April 2013. The coolest months were in June, July, and August 2013.

Studies done by Silim (2006) on pigeonpeas, indicated that for accelerated time to flower and maturity in medium duration genotypes, lower optimum temperature is necessary. This is confirmed by the accelerated flowering of the genotypes at KYM (93 d), with mean temperatures of 23.8°C, which was lower than Kiboko by 1.7^{0}C and delayed flowering at Kiboko (121 d), with a mean temperature of 25.5°C. KIONZA, a long duration local genotype, flowered when the mean temperatures were low with mean temperature of 22.3°C at KYM and 21.7°C at Kiboko, which was below the mean temperature for the locations at flowering of 24°C at KYM and 25°C at Kiboko. This flowering characteristic of KIONZA has been explained by Silim *et al.,* (2006), who observed that long-duration genotypes exhibited delay in flowering and maturity under low temperature and failed to flower when mean temperature reached 26°C. Singh *et al.,* (1997) observed that long duration pigeonpea cultivars, such as KIONZA, are well adapted to cold conditions because of their inherent genetic mechanism to cope with very low temperature during the reproductive stages

Table 5: Mean Monthly temperature and total rainfall during the 2012/13 season and long-term mean at Kambi ya Mawe and KIBOKO in Eastern Kenya

Month/Year	Temperature (°C)						Rainfall (mm)					
	KYM 6 Years (Long Term) 2007-2012	KIB 10 Years (Long Term) 2003-2013	KYM (2011-12)	KIB (2011-12)	KYM (2012-13)	KIB (2012-13)	KYM 6 Years (Long Term) 2007-2013	KIB 10 Years (Long Term) 2003-2014	KYM (2011-12)	KIB (2011-12)	KYM (2012-13)	KIB (2012-13)
October, 12	24	25	24	25	24	25	22.2	19.0	29.1	9.0	21.8	0.0
November, 12	24	25	24	26	24	26	130.2	103.8	171.1	21.4	171.0	21.4
December, 12	24	24	23	24	23	24	70.4	89.8	206.1	99.6	207.2	108.4
January, 13	25	25	26	24	23	25	28.3	41.3	0.0	6.0	54.5	29.4
February, 13	25	26	25	25	24	25	16.4	21.4	7.6	24.0	12.3	0.0
March, 13	25	26	25	26	25	27	60.6	95.7	1.7	16.5	125.0	55.8
Season 1	**25**	**25**	**25**	**25**	**24**	**25**	**328**	**371**	**416**	**177**	**592**	**215**
April, 13	25	26	24	25	24	26	75.1	90.2	187.4	201.2	112.0	278.0
May, 13	25	24	23	24	23	23	30.7	19.4	28.5	51.8	7.8	36.0
June, 13	23	22	21	18	21	21	2.8	2.4	25.7	23.5	1.5	0.0
July, 13	22	21	21	21	20	21	0.0	0.5	0.4	0.0	1.1	3.0
August, 13	22	22	22	22	20	22	1.4	1.1	9.7	1.2	0.9	0.0
Season 2	**23**	**23**	**22**	**22**	**22**	**23**	**110**	**113.6**	**251.7**	**277.7**	**123.3**	**317**
Mean/Total	**24**	**24**	**23**	**24**	**23**	**24**	**438.1**	**484.4**	**667.3**	**454.2**	**715.1**	**532.0**

KYM-Kambi Ya Mawe; KIB - Kiboko

3.9.3 INFLUENCE OF LOCATION AND SUPPLEMENTARY IRRIGATION

Improved soil moisture at Kiboko, as a result of supplementary irrigation improved all the characters, except on shelling percent, which recorded a negative seven (-7) percent, as presented in Table 6. Plant height was the most influenced by 105 percent, followed by grain weight, 47 percent, duration to flower and maturity at 30 and 29 percent respectively. Pod length, pod width and 100 seed mass recorded a 6, 8, and 8 percent enhancement respectively.

Table 6: The effect of location and supplementary irrigation on yield variables at Kiboko and Kambi ya Mawe during the 2012-13 planting seasons

Variable	Kambi ya Mawe (Rain fed)	Kiboko (Supplementary Irrigation)
Duration to Flower (Days)	93	121
Duration to Mature (Days)	116	150
Seed/Pod (No.)	5	6
Pods/Plant (No.)	107	140
Primary Branches (No.)	15	17
Secondary Branches (No.)	27	31
Pod Length (Cm)	8	8
Pod Width (Cm)	1	1
Pod + Grain (Kg/ha)	6,922	7,958
Grain Wt. (Kg/ha)	4,005	5,881
Plant Height (Cm)	117	240
100 Seed Mass (grams)	25	27
Shelling (Percent)	55	51

3.9.4 PLANT HEIGHT

The performance of genotypes on plant height per locations and seasons are presented on table 7, while Mean squares for combined ANOVA are presented on table 13a and 13b. Plant height was highly significant during the Main Crop at both locations ($P \leq 0.001$), but not during the Ratoon Crops ($P<0.005$) among the genotypes. In combined analysis, location, genotype and seasons had a significant influence on the plant height ($P<0.0001$). At KYM, during the Main Crop, plant height ranged between 146.7cm (Mthawajuni) and 174.7cm (ICEAP 00068), with a mean height of 168.6 cm, while during Ratoon Crop, it ranged from

164.7cm (MZ 2/9) to 201.7cm (ICEAP 00911), with a mean of 180.4cm, for the test genotypes. At Kiboko, the plant height ranged from 206.3cm (KAT 60/8) to 241.7cm (ICEAP 00557), with a mean of 226.8cm during Main Crop, and 202.7cm (ICEAP 00911) to 267.0cm (ICEAP 00902), with a mean of 239.5cm, during the ratoon. While KIONZA was 82.2cm (51 percent) taller than the test genotypes at KYM, it was 78cm (26 percent) taller than the test genotypes at Kiboko.

Table 7: Mean plant height of pigeon pea genotypes grown at Kiboko and Kambi ya Mawe during the main crop and ratoon seasons in 2011-2012 and 2012-2013 cropping years.

	Plant Height (cm)			
	Kambi Ya Mawe		**Kiboko**	
Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
KAT 60/8	156.9b	177.7	206.3b	239.7
ICEAP 00554	173.8a	194.3	225b	243.0
MZ 2/9	166.5b	164.7	224.3b	234.3
ICEAP 00068	174.7a	177.3	235b	260.7
ICEAP 00911	156.9b	201.7	221.7b	222.7
ICEAP 00850	164.2b	179.7	234.3b	254.0
ICP 7035B	148.9b	167.7	219.3b	220.3
ICEAP 00902	169.5b	191.3	240a	267.0
ICEAP 00540	155.4b	176.0	227.3b	211.3
MTAWAJUNI	146.7b	180.0	220b	245.3
ICEAP 00557	166.1b	173.7	241.7b	256.3
KIONZA	244a	N/A	304.3a	N/A
MSS-Variety	**1934*****	**377.4^{NS}**	**1795.6*****	**1286.5^{NS}**
LSD $_{(0.05)\ Genotype}$	**19.12*****	**33.82^{NS}**	**21.46*****	**50.94^{NS}**
CV% Genotype	**6.7**	**11**	**5.4**	**12.5**
LSD (0.05) Location	**5.8*****	12.3***		
LSD (0.05) G x L	**20.0^{NS}**	42.8^{NS}		
CV% Location	**6.1**	12.4		

, **, *, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively*

Means with the same letter are not significantly different

Improved soil moisture, as a result of supplementary irrigation had a positive influence on the plant height during both seasons. The most effect was felt, during the main crop, with an increase of 65cm and a 61 percent during the Ratoon Crop. ICEAP 00557 was the most influenced by irrigation, with height increase of 75.6cm, followed by Mthawajuni (73.3cm) during the Main Crop, as compared to Kambi ya Mawe. ICEAP 00068, ICEAP 00557 and ICEAP 00902 were the most influenced during the Ratoon Crop, with 83.4cm, 82.6cm and 75.7cm increase respectively, compared to Kambi ya Mawe. ICEAP 00911 (21cm), ICEAP (35cm) and ICEAP 00554 (49cm) responded least during ratoon, to irrigation at Kiboko compared to Kambi ya Mawe, in terms of difference in plant height (cm), while KAT 60/8 (49cm), ICEAP 00554 (51cm) and MZ 2/9 (58cm) responded least during the Main Crop.

The significant influence of location and interaction between location and genotype on plant height, was similar to the observation made by Egbe and Vange (2008) that plant height in pigeon pea is affected by maturity duration, genotype, and environment. Reddy (1990) observed that late-maturing long-duration genotypes are generally tall, because of their prolonged vegetative phase. Khourgami (2012) reported that Supplementary irrigation increases the plant height in pigeon pea by a mean height of 34.4cm, which he associated to prolonged plant growth period, increased vegetative growth, leading to production of taller plants. Felix (2009) reported increase in plant height of beans under supplementary irrigation, while Attia (2013), reported increase in plant height in Faba beans.

3.10 YIELDS AND YIELD COMPONENTS

3.10.1 GRAIN AND POD YIELD

The genotype performance on grain yields at both locations and seasons are presented in the table 8. There was no significant difference among the genotypes on grain and pod yields $(P<0.05)$ at both locations. The effect of location was significant only during ratoon (P<

0.001), while interaction between location and genotypes (G x L) was significant at (P<0.01) during the Ratoon Crop. During the Main Crop, the grain yields varied from 1,132 Kg/ha (ICEAP 00850) to 2,905 Kg/ha (MZ 2/9), with a mean of 1,988 Kg/ha, while during ratoon, it ranged from 1,044 Kg/ha (ICP 7035B) and 3,054 Kg/ha (MZ 2/9), with a mean of 1,962 Kg/ha, at Kambi Ya Mawe.

Table 8: Performance of vegetable pigeonpea genotype on grain yield (Kg/ha) at Kambi ya Mawe and Kiboko during crop and Ratoon Crops during the 2012/13 season.

		Grain Yield (Kg/ha)					
		Kambi Ya Mawe			Kiboko		
	Variety	Crop	Ratoon	Total	Crop	Ratoon	**Total**
1	ICP 7035B	1,997	1,044	3,041	1,803	3,933	5,736
2	ICEAP 00068	2,455	2,580	5,035	2,587	3,274	5,861
3	ICEAP 00850	1,132	1,730	2,862	1,810	3,606	5,416
4	ICEAP 00554	1,309	2,210	3,519	1,899	4,321	6,220
5	ICEAP 00557	1,708	1,380	3,088	2,040	4,124	6,164
6	ICEAP 00540	2,010	1,613	3,623	1,887	3,545	5,432
7	KAT 60/8	2,069	1,315	3,384	2,640	4,702	7,342
8	MTAWAJUNI	2,388	1,566	3,954	2,718	4,639	7,357
9	MZ 2/9	2,905	3,054	5,959	3,444	4,119	7,563
10	ICEAP 00911	2,851	2,448	5,299	2,322	3,158	5,480
11	ICEAP 00902	1,648	2,642	4,290	2,229	3,926	6,155
12	KIONZA	1,379		1,379	1,843		1,843
	Mean	**1,988**	**1,962**	**3,786**	**2,269**	**3,941**	**5,881**
	CV%	**30.1**	**37.2**		**30.5**	**19.3**	
	LSD $_{(0.05)\ Genotype}$	**1012.1NS**	**1241.8NS**		**1169NS**	**1296.7NS**	
	LSD (0.05) Location	**322NS**	**379*****				
	LSD (0.05) G x L	**1119NS**	**1314****				
	CV% (Location)	**32**	**27**				

, **, *, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively*
Means with the same letter are not significantly different

The yields reduced by 26 Kg/ha (1.3 percent) during the Ratoon Crop as a result of reduced rainfall by 380 percent from 592mm during the crop to 123mm during ratoon. At Kiboko, grain yields varied from 1,803 Kg/ha (ICP 7035B) and 3,444 Kg/ha (MZ 2/9), with a mean of

2,269 Kg/ha during the Main Crop and 3,933 Kg/ha (ICP 7035B) to 4,119 Kg/ha (MZ 2/9), with a mean of 3,941 Kg/ha, during Ratoon Crop. The Grain yields were enhanced by 74 percent during the Ratoon Crop, compared to the Main Crop at Kiboko. This was due to enhanced rainfall at Kiboko, which increased by 47 percent, from 215mm during Main Crop to 317mm during Ratoon Crop, in addition to supplementary irrigation. Yields were enhanced by 14 percent at Kiboko during the Main Crop, and 101 percent during the Ratoon Crop, when compared to KYM. MZ 2/9, ICEAP 00068, and ICEAP 00902 produced higher mean yields at both locations while ICP 7035B, ICEAP 00850 and ICEAP 00540 were consistently lower. KIONZA, a local landrace performed poorly compared to the test genotypes by 44 percent at KYM (1,379 Kg/ha) and 23 percent at Kiboko (1,843 Kg/ha). The non-significance difference among the genotypes on grains and pods was expected since these genotypes were initially selected based on grain yields at both on-station and on-farm. Similar results have been reported by Onyango and Silim (2000), while evaluating short duration pigeonpea genotypes at Kiboko.

This study has observed that delay in maturity leads to reduced yields in vegetable pigeonpeas, as indicated by the negative but non-significant correlation between duration to flower/maturity and grain yield at both locations. Late maturing genotypes with a mean of 122 DTF, gave low yields of 3,839 Kg/ha, compared to early maturing genotypes with a mean of 100 DTF, had a mean yield of 5,754 Kg/ha. KIONZA, a local check genotype took longer to attain 50 percent flowering (217 days at Kiboko and 181 days at KYM). Consequently, it was affected by the reduced amount of rainfall during the Ratoon Crop, leading to 48% reduction in yield, compared to the test genotypes at Kambi ya Mawe. Gwata and Shimelis, (2013), Gwata and Silim, (2009), Upathayaya *et al.*, (2006) and Snapp *et al.*, (2003), observed that delay in flowering and maturity lead to increased susceptibility to terminal drought. Cooper (2003) observed that in soya bean, earlier flowering could significantly increase yield potential. Supplementary irrigation improved grain yields by 14 percent (281 Kg/ha) during main crop and 100 percent (1,979 Kg/ha) during the Ratoon Crop. The greatest yield difference was observed during Ratoon Crop, due to enhanced rainfall at Kiboko by 47 percent (317mm compared to main crop of 215mm). Low percent difference in yield during the Main Crop between the locations, was due to good rains received at KYM of 592mm, which was 175 percent above that at Kiboko.

Significant increase in yield under supplementary irrigation has been attributed to relative reduction of water stress during flowering stage and prolonged seed filling period, leading to improved 100 seeds weight. Similar results have been reported by Khourgami, (2012), on lentils and Anwar *et al.*, (2003) in chickpeas with grain yield and pods per plant, being increased by 17.03 percent and 48 percent respectively. Khourgami (2012) recorded 1,559 Kg/ha while Pezeshkpour *et al.*, (2008) recorded 678Kg/ha enhanced yields on pigeon peas due to Supplementary irrigation. Zhang *et al.*, (2000) observed a 100 percent increase in yield under supplementary irrigation, compared to rain fed condition for chickpeas. Similar results have been observed by Gupta *et al.*, (2005) on lentil and Zhang *et al.*, (2000) on lentils and chickpeas while Felix, (2009) observed a 39 percent increase in yield of Beans.

Based on yield (Kg/ha), this study has been able to identify genotypes that performed well across the locations. These were MZ 2/9 (5,959/7,563), ICEAP 00068 (5,035/5,861), ICEAP 00902 (4,290/6,155), Mthawajuni (3,954/7,357), ICEAP 00554 (3,519/6,220) and KAT 60/8 (3,384/7,342) for Kambi ya Mawe and Kiboko respectively, in Kg/ha. While ICEAP 00911 (5,299) performed better at KYM, ICP 7035B (5736) performed better at Kiboko under supplementary irrigation. Potentially, all the genotypes, have the chances of being promoted as vegetable pigeonpeas, given the lack of significance based on yields.

3.10.2 PODS PER PLANT

The Mean pods per plant, per locations and seasons are presented on table 9 below and Mean squares for combined ANOVA are presented on table 13a and 13b. There was no significant ($P\leq 0.05$) difference among genotypes at both locations and season for pods per plant, indicating lack adequate genetic variability among genotypes. The study observed a significant effect of location during both crop ($P<0.01$) and Ratoon ($P<0.001$). The interaction between genotype and location was only significant during Ratoon Crop ($P<0.001$). There was an increase in number pods per plant at KYM by 16 percent and Kiboko by 14 percent during Ratoon Crop. The pods per plant ranged between 85.2 (ICEAP 00850) to 132.3 (ICP 7035B), with a mean of 98.5 pods per plant at Kambi Ya Mawe, during the main Crop, while during the Ratoon Crop, a range of 78.1 (ICEAP 00068) to 140.3 (MZ 2/9), with a mean of 116 pods per plant was observed. Compared to KIONZA, the test genotypes had inferior number of pods by 18 percent at KYM and 1.6 percent at Kiboko.

At Kiboko, the pods per plant ranged from 65.3 (ICEAP 00554) to 205.3 (ICEAP 00911), with a mean of 131.4 pods plant during the Main Crop and was between 121.3 (Mthawajuni) to 139.8 (ICEAP 00540), with a mean of 139.8 during Ratoon Crop. The Ratoon Crop had a superior number of pods per plant by 6%, compared to the Main Crop. Supplementary irrigation increased the number of pods per plant by 32.9 pods, during the crop and Ratoon Crops. Irrigated plants also produced more primary and secondary branches, increasing the number of locations available for pods. During the Main Crop, ICEAP 00554 and MZ 2/9 had a low number of pods at Kiboko, by 33.1 and 1.6 respectively, while ICEAP 00911 and ICP

7035B had number of pods enhanced at Kiboko by 92 and 80 respectively.

Table 9: Mean pod length (cm) and pod width (cm) of pigeon pea genotypes evaluated at Kiboko and Kambi ya Mawe locations in Eastern Kenya in 2011-2012 and 2012-2013 cropping years.

		Pods Per Plant			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	132.3	123.6	203.7	138.5
2	ICEAP 00068	93.2	62.9	139.0	139.3
3	ICEAP 00850	85.2	122.5	98.3	164.3
4	ICEAP 00554	98.4	118.0	65.3	167.1
5	ICEAP 00557	89.3	129.1	101.9	153.6
6	ICEAP 00540	87.2	73.4	96.1	183.5
7	KAT 60/8	85.3	101.9	130.3	153.5
8	MTAWAJUNI	89.2	106.4	116.7	125.8
9	MZ 2/9	115.2	165.3	113.6	139.9
10	ICEAP 00911	113.1	109.0	205.3	141.2
11	ICEAP 00902	95.0	164.2	175.3	131.3
12	KIONZA	116.0	N/A	129.3	N/A
MSS-Variety		**710^{NS}**	**2999^{NS}**	**5670^{NS}**	**898.7^{NS}**
CV%		**36.4**	**31.2**	**40.8**	**18.9**
CV% Location		**40.6**		**25.9**	
LSD $_{(0.05)}$		**61.63**	**61.6**	**90.6**	**48.03**
LSD (0.05) Location		**22.2****	**16.3*****		
LSD (0.05) G x L		**77.0NS**	**56.4***		

*, **, ***, NS significant at P≤0.05, P≤0.01, and P≤0.001 and Non-Significant respectively.

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

During the ratoon crop, ICEAP 00902 and MZ 2/9 recorded reduced pods by 32.9 and 25.4 respectively, ICEAP 00540 and ICEAP 00068 by 110 and 76 pods respectively, compared to Main Crop.

3.10.3 DURATION TO FLOWER AND MATURITY

The Mean Days to flowering and maturity at both locations are presented in table 10, below, while ANOVA tables are presented in Table 13a and 13b.

Table 10: Flower development and maturity (days) in pigeon pea genotypes grown at Kiboko and Kambi ya Mawe locations during Main crop season in 2012-2013

	Days to 50% Flower		**Days to 75% Mature**	
Genotypes	**KYM**	**KIB**	**KYM**	**KIB**
ICP 7035B	82.0c	109.7bc	103.0b	137.0bc
ICEAP 00068	88.3bc	113.0bc	108.7b	140.0bc
ICEAP 00850	90.7bc	119.0b	111.0b	141.0bc
ICEAP 00554	87.3bc	119.3b	112.7b	146.7b
ICEAP 00557	87.7bc	114.3bc	105.7b	144.0bc
ICEAP 00540	85.0bc	109.0bc	104.7b	142.7bc
KAT 60/8	78.0c	103.3c	102.0b	138.0bc
MTAWAJUNI	80.0c	107.3bc	107.0b	130.0c
MZ 2/9	81.0c	119.0b	105.0b	146.7b
ICEAP 00911	84.0c	108.0bc	103.3b	135.3bc
ICEAP 00902	96.0a	115.7bc	110.7b	142.7bc
KIONZA	180.7a	216.7a	215.3a	252.7a
Mean	**93.39**	**121.19**	**115.76**	**149.73**
CV% $_{\text{genotype}}$	4.90	3.50	5.00	3.30
LSD $_{(0.05)\ \text{Genotype (G)}}$	7.78***	7.26***	9.81***	8.45***
LSD $_{(0.05)\ \text{Location (L)}}$	3.4***		2.6***	
LSD $_{(0.05)\ \text{Loc x Genotype}}$	8.1***		8.9*	
CV% $_{\text{Location}}$	4.6		4.1	

, **, ***, NS significant at P≤0.05, P≤0.01, and P≤0.001 and Non-Significant respectively
Means with the same letter are not significantly different

There was significant difference in flowering at 50% and maturity at 75%, between the genotypes (P<0.001), indicating the presence of adequate genetic variability among all the tested genotypes. Location had a significant influence (P<0.001) on duration to flower and maturity. Interaction between location and genotype, was also significant (p<0.001), as presented in Table10 below. This indicates that duration to flower and maturity is not only influenced by the genotype, but also by the environment, and their interaction.

The genotypes flowered early at Kambi ya Mawe (93.4 days), with genotypes ranging between 78 and 181 days, 28 days earlier that those at Kiboko. Kiboko recorded a mean of 121 days, with a range of 103-217 days to flower. Compared to the test genotypes, KIONZA flowered late at KYM by 96 days (53% above) and 104 days (48% above) at Kiboko. KAT 60/8 (78 d), Mthawajuni (80), MZ 2/9 (81) and ICP 7035B (82) flowered significantly early at Kambi ya Mawe, while at Kiboko, Kat 60/8 (103), Mthawajuni (107), ICP 7035B (110), ICEAP 00540 (109) and ICEAP 00911 (108), flowered early. KAT 60/8, Mthawajuni, and ICP 7035B flowered early at both locations. KAT 60/8 (102), ICP 7035B (103) and ICEAP 00911(103) matured significantly early at KYM, while Mthawajuni (130), ICEAP 00911 (135), ICP 7035B (137) and Kat 60/8 (138), matured significantly early at Kiboko.

The mean genotype range for DTF, was within the range observed by Remanadan *et al.*, (1990) of 55-237, among 10,670 accessions evaluated in India, and the range given for Kenya by Silim (2001) and Mergeai *et al.*, (2001). The earliness in flowering of the medium duration genotypes at Kambi ya Mawe, have been reported by Manyasa *et al.*, (2009), when evaluating Uganda germplasm at Kabete and Kambi ya Mawe. Interaction between location and genotypes, which was significant in this study, was also reported by reported by Makelo *et al.*, (2013) in chickpeas and pigeonpeas respectively. Supplementary irrigation delayed flowering at Kiboko by 28d and maturity by 34d. The most affected genotype was MZ 2/9 by 38 days to flower and 42 days to maturity. The least affected was ICEAP 00902 by 20 days to flower and

Mthawajuni by 23 days to maturity. Delay in days to flowering and maturity under supplementary irrigation has also been reported by Felix (2009) in Beans. Deshmukh and Mate (2013) reported that days to flowering were hastened by 5-6 days due to moisture stress condition, while maturity was delayed by 10-14 days by irrigating the pigeonpeas crops.

3.10.4 SEED WEIGHT (g/100 SEEDS)

The Mean genotype performance on seed mass per locations and seasons are presented on table 11, while Mean squares for combined ANOVA are presented on table 13a and 13b. There was high significance difference in seed Mass ($P < 0.001$) among genotypes at both locations, and seasons. Interaction between location and genotypes, Season and Genotype, were also significant ($P<0.05$) and ($P<0.01$) respectively (Table 11). KIONZA, recorded 39 percent above the test genotypes based seed mass at KYM and 45 percent at Kiboko. 100 Seed mass ranged between 19.4 grams (ICEAP 00554) and 31.6 grams (MZ 2/9) with a mean of 22.4 gram/100 seed, during the Main Crop at Kambi ya Mawe, and 22.7 grams (KAT 60/8) and 40.3 grams (MZ 2/9), with a mean of 26.7 grams during the Ratoon Crop at the same location. Seed mass improved at KYM during Ratoon Crop by 19 percent. Seed mass ranged between 20.9 grams (ICEAP 00902) and 32.7 (MZ 2/9), with a mean seed mass of 25.2 grams during Main Crop at Kiboko and 24.6 grams (ICEAP 00850) and 38.5 grams (MZ 2/9), with a mean of 27.8 grams during the Ratoon Crop at the same location. Seed mass at Kiboko was also improved during Ratoon Crop by 10 percent. 100 seed mass was enhanced by supplementary irrigation, with Kiboko recording a mean higher weight of 27 grams, 8 percent above that recorded at KYM of 25 gram. Saritha *et al.*, (2012) reported a significantly lower 100 seed weight in pigeonpea grown under rain-fed condition, due to moisture stress, affecting translocation of photosynthesis from leaves to grain, resulting in small grains.

Table 11: Mean seed weight (g/100 seeds) at Kambi ya Mawe and Kiboko during crop and Ratoon Crop-2012/13.

		100 seed Weight (Gms)			
		Kambi Ya Mawe		Kiboko	
	Genotype	Main Crop	Ratoon Crop	Main Crop	Ratoon Crop
1	ICP 7035B	22.56bcd	27.83bd	24.49cd	27.16bc
2	ICEAP 00068	24.22bc	25.52c	25.86cd	26.59bc
3	ICEAP 00850	19.78cd	23.13c	22.25d	26.89bc
4	ICEAP 00554	19.44d	22.5c	25cd	25.92bc
5	ICEAP 00557	21.11cd	25.17c	24.45cd	27.26bc
6	ICEAP 00540	21.11cd	24.7c	24.94cd	24.8c
7	KAT 60/8	19.89cd	22.67c	23.14cd	24.63c
8	MTAWAJUNI	26.22b	31.33b	29.08bc	31.75b
9	MZ 2/9	31.56a	40.33a	32.67ab	38.54a
10	ICEAP 00911	20cd	23.65c	24cd	25.57bc
11	ICEAP 00902	20.89cd	26.7bc	20.93d	26.85bc
12	KIONZA	31.11a	N/A	36.57a	N/A
MSS-Variety		**55.65*****	**81.69*****	**61.14*****	**48.71*****
LSD (0.05) Genotype		**2.548**	**3.252**	**3.535**	**3.67**
CV% Genotype		**6.5**	**7.2**	**8.0**	**7.7**
LSD (0.05) Location		**0.9*****	**1.1***		
LSD (0.05) G x L		**2.9^{NS}**	**3.7^{NS}**		
CV% Location		**7.2**	**8.1**		

, **, *, NS significant at P≤0.05, P≤0.01, and P≤0.001 and Non-Significant respectively*

Means with the same letter are not significantly different

3.10.5 SHELLING PERCENTAGE

The shelling percentage defined as the percentage of grain yield to the unshelled pod mass. (IBPGR & ICRISAT, 1993). The Mean shelling percent per locations and seasons are presented on table 12, while Mean squares for combined ANOVA are presented on table 13a and 13b. There was no significant difference among the genotypes on shelling percentage within the locations and between seasons at (p<0.05). There was a significant effect of location (P<0.001) and Season (P<0.001) on shelling percent. Shelling percent ranged from

53.6 percent (ICEAP 00850) to 63.1 percent (MZ 2/9), with a mean of 56.7 percent at crop and 48 percent (ICEAP 00850) to 63 percent (MZ 2/9), with a mean of 53 percent during the Ratoon Crop at Kambi ya Mawe.

Table 12: Shelling percent (%) at Kiboko and Kambi ya Mawe during the crop and Ratoon Crop-2012/13

		Shelling Percent			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	54.8	54.1	54.9	52.8
2	ICEAP 00068	55.1	52.1	52.5	48.1
3	ICEAP 00850	53.6	50.0	47.1	44.6
4	ICEAP 00554	53.6	51.7	54.0	51.3
5	ICEAP 00557	54.4	56.3	49.8	46.3
6	ICEAP 00540	56.8	47.5	51.8	48.1
7	KAT 60/8	59.7	49.8	60.7	55.3
8	MTAWAJUNI	57.9	52.9	56.0	52.4
9	MZ 2/9	63.1	62.9	47.2	48.2
10	ICEAP 00911	58.1	53.8	52.8	48.2
11	ICEAP 00902	56.3	55.2	52.5	48.7
12	KIONZA	44.0	N/A	51.2	N/A
MSS-Variety		**63.58^{NS}**	**49.9^{NS}**	**42.16^{NS}**	**29.7^{NS}**
LSD $_{(0.05)}$		**9.81**	**8.141**	**11.71**	**9.54**
CV%		**10.4**	**9.0**	**13.2**	**11.3**
LSD (0.05) Location		**3.0***	**2.5***		
LSD (0.05) G x L		**10.3^{NS}**	**8.7^{NS}**		
CV% Location		**11.6**	**10.2**		

, **, ***, NS significant at P≤0.05, P≤0.01, and P≤0.001 and Non-Significant respectively

Means with the same letter are not significantly different

At Kiboko, shelling percent ranged between 47 percent (ICEAP 00850) and 60.7 percent (MZ 2/9), with a mean of 52.7 percent, during the main crop, and 44.6 percent (ICEAP 00850) to 55.3 percent (KAT 60/8), with a mean of 49.4 percent during Ratoon Crops. While the shelling percent was reduced during Ratoon Crop by 4 percent, at KYM, it reduced by 7 percent at Kiboko. KIONZA recorded a lower shelling percent at both locations, recording 44 percent at KYM and 51 percent at Kiboko. Genotypes under supplementary irrigation recorded a lower shelling percent by 7.5 percent during crop and 7.2 percent during Ratoon Crops. Under supplementary irrigation, the shelling percent was lower during both seasons. This study observed that early maturing genotypes realized a higher shelling percentage of 59 percent at KYM and 55 percent at Kiboko, compared to the late maturing genotypes which realized 52 percent at KYM and 50 percent at Kiboko respectively, as presented in Table 14 below. Locations where the genotypes are taking longer to mature also produce genotypes with lower shelling percent. This confirms the negative correlation between duration to flower/maturity and shelling percent at both locations.

Table 13: Influence of duration to flower on shelling percent of vegetable pigeonpea genotypes at Kiboko and Kambi ya Mawe during the Main Crop-2012/13

Early Flowering				**Late Flowering**		
Location	**Genotype**	**DTF**	**Shelling %**	**Genotype**	**DTF**	**Shelling %**
Kambi ya Mawe	MZ 2/9	81	63.1	KIONZA	181	44.0
	KAT 60/8	78	59.7	ICEAP 00850	91	53.6
	ICEAP 00911	84	58.1	ICEAP 00902	96	56.3
	Mthawajuni	80	57.9	ICEAP 00557	88	54.4
	ICP 7035B	82	54.8	ICEAP 00068	88	55.1
Mean		**81**	**58.7**		**109**	**52.7**
Kiboko	KAT 60/8	103	60.7	ICEAP 00850	119	47.1
	Mthawajuni	107	56.0	MZ 2/9	119	47.2
	ICP 7035B	110	54.9	ICEAP 00554	119	54.0
	ICEAP 00540	109	51.8	KIONZA	216	51.2
	ICEAP 00911	108	52.8	ICEAP 00902	116	52.8
Mean		**107**	**55.2**		**138**	**50.5**

DTF: Days to flower

Table 14a: Analysis of variance on the effect of genotypes, locations, and cropping seasons on pigeon pea growth parameters in 2011-2012 and 2012-2013 cropping years.

Source	Days to 50% Flower	Days to 75% Flower	Grain Yield (Kg/ha)	Pods + Grain (Kg/ha)	Shelling %	100 Seed Mass (gms)	Pods per Plant (Count)
Site	19848***	6818***	41210192***	208970318***	409***	149.7***	35426***
Variety	10091***	11336***	1940832***	5268375***	65.8*	203.4***	2472NS
Site x Variety	79.9***	172***	908172NS	2642513NS	80.8*	7.3*	1655NS
Season	199759***	176295***	19881186***	108853058***	356***	393***	10126*
Season x Variety	107***	80.81NS	600132NS	2150358NS	17NS	10.5**	3409*
CV %	**6.68**	**7.67**	**28.6**	**26.82**	**10.87**	**7.53**	**33.38**
SE	**4.42**	**7.17**	**721.3**	**1298**	**5.74**	**1.95**	**41.29**

Table 13b: Analysis of variance on the effect of genotypes, locations, and cropping seasons on pigeon pea growth parameters in 2011-2012 and 2012-2013 cropping years.

Source	Seed Per Pod (Count)	Secondary Branches (Count)	Primary Branches (Count)	Plant Height (cm)	Pod Width (cm)	Pod Length (cm)
Site	12.1***	696***	136***	132692***	0.335***	10.4***
Variety	1.9***	457***	21***	3628***	0.095***	2.99***
Site x Variety	0.49NS	277***	24***	484.7NS	0.0069NS	0.707NS
Season	0.61NS	346*	309***	8071***	0.004NS	1.63NS
Season x Variety	0.51NS	0.38NS	0.443NS	235NS	0.014NS	0.72NS
CV %	**12.8**	**26.4**	**14.4**	**9.43**	**10.6**	**10.9**
SE	**0.69**	**7.66**	**2.38**	**19.4**	**0.123**	**0.86**

, **, *, NS significant at P≤0.05, P≤0.01, and P≤0.001 and Non-Significant respectively. Turkey, (p<0.05)*

Supplementary irrigation had a negative effect on the shelling percentage, for most genotypes, with MZ 2/9 the most affected with a reduction of 15.9 percent, while KIONZA, responded positively, with an increase of 7.2 percent. During the Ratoon Crop, MZ 2/9 was again the most affected by14.6 percent reduction, while KAT 60/8's shelling percent reduced by 5.6 percent. The shelling percent was reduced by 3.1 percent during crop, and 3.9 percent during Ratoon Crop. Overall reduction in shelling percent as a result of supplementary irrigation was 7 percent. Information available in the literature is limited on the effect of moisture stress.

3.10.6 SEED PER POD

The Mean performance of genotypes on seed per pod per locations and seasons are presented on Table 15, while Mean squares for combined ANOVA are presented in table 13a and 13b. There was significant difference on the number of seeds per pod at KYM ($P<0.001$) and Kiboko ($P<0.05$) during the Main Crop. There was no significant difference among the genotypes on seed per pod during the Ratoon Crop at both locations ($P<0.05$). The interaction between location x genotype and season x genotype was also not significant. During the Main Crop, seed per pod at KYM ranged from 4.8 (Mthawajuni) to 5.2 (ICEAP 00902), with a mean of 5.1, while at Kiboko, it ranged from 5.0 (ICEAP 00911) to 6.0 (ICEAP 00554), with a mean of 5.6. At both locations, KONZA recorded 7.0. During the Ratoon Crop, Kambi ya Mawe had a range of 4.7 (Mthawajuni) to 6.0 (ICEAP 00540), with a mean of 5.2 seeds, while Kiboko had a range of 5.0 (Mthawajuni) to 6.3 (ICEAP 00554), with a mean of 5.8 seeds.

The study observed an increase in number of seeds per pod at Kiboko compared to KYM as a result of supplementary irrigation. Significant difference among genotypes on seed per pod have also been reported by Roz-Rokh *et al.,* (2009) on chickpeas. Fallah (2008) observed that chickpea plants with higher number of pods, pods exacerbate competition for assimilates, resulting in formation of a lower seed number and size. Number of seeds per pod correlated positively to pod length/width and 100 seed mass during the Main Crop. Increase in pod length increases the number of ovules, which have enhanced weight as a result of enough space for expansion. Udensi and Ikpeme (2012) and Baskaran and Muthiah, (2007) have also reported the same results in Pigeonpeas. This study has observed a 12 percent increase in number of seeds per pod at Kiboko, as a result of supplementary irrigation. Ahlawat and Sharma (1989) reported that increase in irrigation frequency increased the number of seed per pod and 100 seed weight in French beans. Similar results have been reported by Mozumder *et al.*, (2005) on Bush beans.

Table 15: Mean Seed per pod at Kiboko and Kambi ya Mawe during the crop and Ratoon Crop during 2012-13 season

		Seed per Pod			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	5.1b	5.0	6.0ab	5.7
2	ICEAP 00068	5.1b	5.0	5.7b	6.3
3	ICEAP 00850	5.0b	5.3	5.7b	6.3
4	ICEAP 00554	5.2b	5.7	6.0ab	6.3
5	ICEAP 00557	5.1b	5.0	6.0ab	6.0
6	ICEAP 00540	5.1b	6.0	5.3b	5.7
7	KAT 60/8	5.2b	5.3	5.3b	5.7
8	MTAWAJUNI	4.8b	4.7	5.3b	5.0
9	MZ 2/9	4.9b	5.0	5.3b	5.3
10	ICEAP 00911	4.9b	5.3	5.0b	6.0
11	ICEAP 00902	5.2b	4.7	5.7b	5.7
12	KIONZA	7.0a	N/A	7.0a	N/A
MSS-Variety		**1.0*****	**0.87^{NS}**	**0.82****	**0.57^{NS}**
CV%		**5.9**	**23.7**	**7.7**	**7.7**
CV% Location		**7.2**		**17.3**	
LSD $_{(0.05)}$		**0.519**	**2.054**	**0.747**	**0.767**
LSD (0.05) Location		**0.2*****	**0.5*****		
LSD (0.05) G x L		**1.6NS**	**1.6NS**		

*, **, ***, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively.

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

3.10.7 PRIMARY AND SECONDARY BRANCHES

The Mean primary and secondary branches per genotype, locations, and seasons are presented in table 16 and 17 respectively, while Mean squares for combined ANOVA are presented on table 13a and 13b.

Table 16: Number of Primary Branches at Kiboko and Kambi ya Mawe during the Main Crop and Ratoon Crops - 2012/13.

		Primary Branches			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	17.0	20.2	16.3bc	18.9ab
2	ICEAP 00068	13.7	17.0	15bc	17.7ab
3	ICEAP 00850	13.7	16.8	16.3bc	18.7ab
4	ICEAP 00554	11.0	15.4	16bc	19.4ab
5	ICEAP 00557	12.0	14.1	19.3ab	21.9a
6	ICEAP 00540	14.0	16.9	15.3bc	18.9ab
7	KAT 60/8	13.7	16.0	14bc	18.1ab
8	MTAWAJUNI	12.0	15.1	15.3bc	18.6ab
9	MZ 2/9	14.7	17.6	11.7c	14.7b
10	ICEAP 00911	16.0	18.0	14.7bc	18.6ab
11	ICEAP 00902	15.3	18.7	17.7abc	20.7ab
12	KIONZA	16.8	N/A	23.3a	N/A
MSS-Variety		**10.9^{NS}**	**9.126^{NS}**	**25.5*****	**9.707^{NS}**
LSD $_{(0.05)}$		**2.778**	**4.087**	**3.69**	**3.89**
CV%		**19.6**	**14.2**	**13.4**	**12.2**
LSD (0.05) Location		**1.1*****	**1.1*****		
LSD (0.05) G x L		**4.0****	**3.7***		
CV% Location		**15.9**	**12.7**		

, **, *, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively*
Means with the same letter are not significantly different

While there was no significant difference among the genotypes on the primary branches at KYM during both seasons, at Kiboko, they were significant only during the Main Crop ($P<0.001$). Combined analysis, as presented in table 13a and 13b (Page 58), showed a significant interaction between genotypes, season and location ($P<0.001$), for both primary and secondary branches. During the Main Crop, number of primary branches ranged from 11 (ICEAP 00554) to 17 (ICP 7035B), with a mean of 13.9 and from 14.1(ICEAP 00557) to 20.2 (ICP 7035B), with a mean of 16.9 during the Ratoon Crop at KYM. Kionza had a superior number of primary branches, 21% above the test genotypes.

Primary branches increased by 19% during the Ratoon Crop at KYM, while at Kiboko, it increased by 16%. At Kiboko, the number of primary branches ranged from 11.7 (MZ 2/9) to 19.3 (ICEAP 00557), with a mean of 15.6 during the Main Crop and 14.7 (MZ 2/9) to 21.9 (ICEAP 00557), with a mean of 18.8, during the Ratoon Crop. KIONZA, again, had a superior number of primary branches of 49%, above the test genotypes. Location differences were observed, with Kiboko recording a superior number of primary branches compared to Kambi ya Mawe by 11% during crop and 12% during ratoon. Number of secondary branches ranged from 14.3 (ICEAP 00557) to 43.3 (ICP 7035B), with a mean of 25.1, during Main Crop and 16.4 (ICEAP 00557) to 46.6 (ICP 7035B), with a mean of 28.6, during Ratoon Crop, at KYM as presented in table 17 below. At Kiboko, the mean range was from 14.3 (MZ 2/9) to 37.7 (ICEAP 00902), with a mean of 28.9 during the Main Crop and 17.7 (MZ 2/9) to 39.5 (ICEAP 00902), with a mean of 32 branches during the Ratoon Crop. KIONZA, a local genotype, recorded a superior number of secondary branches at KYM (25.9) which was 3%, and at Kiboko by 71%. Large seasonal difference was observed at KYM, with a 14% increase in secondary branches compared to 10% at Kiboko during Ratoon Crop. Both primary and secondary branches were positively influenced by supplementary irrigation, with primary branches being enhanced by 12 percent and secondary branches by 14 percent. MZ 2/9 and ICP 7035B had their primary branches reduced by 3.0 and 0.7 branches respectively. No results were observed during Ratoon Crop, where MZ 2/9 and ICP 7035B recorded 2.9 and 1.3 reduced branches respectively, at Kiboko. ICEAP 00557 and ICEAP 00554 responded positively to supplementary irrigation, with an increase of 7.3 and 5.0 branches during main crop respectively, compared to Kambi ya Mawe.

Table 17: Number of Secondary branches at Kiboko and Kambi ya Mawe during the Main crop and Ratoon Crop - 2012-13

		Secondary Branches			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	43.33a	46.6a	33.67ab	36.13a
2	ICEAP 00068	27.67ab	31.87ab	22bc	25ab
3	ICEAP 00850	18.67ab	22.6ab	24.67bc	28.07ab
4	ICEAP 00554	22.33ab	25.47ab	29bc	32.2ab
5	ICEAP 00557	14.33b	16.4b	28bc	31ab
6	ICEAP 00540	26.67ab	30.27ab	30bc	33.07ab
7	KAT 60/8	21ab	24.73ab	36ab	38.8a
8	MTAWAJUNI	26ab	29.47ab	34.33ab	37.93a
9	MZ 2/9	17.33ab	20ab	14.33c	17.73b
10	ICEAP 00911	36.33ab	40ab	28.67bc	32.2ab
11	ICEAP 00902	22.33ab	26.67ab	37.67ab	39.47a
12	KIONZA	25.87ab	N/A	49.33a	N/A
MSS-Variety		**196.0***	**226.63***	**229.2*****	**127.4****
LSD $_{(0.05)}$		**15.72**	**16.36**	**9.72**	**9.703**
CV%		**36.7**	**33.6**	**18.7**	**17.8**
LSD (0.05) Location		**3.8****	**3.9^{NS}**		
LSD (0.05) G x L		**13.3***	**13.6^{NS}**		
CV% Location		**29**	**27.3**		

, **, ***, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively

Means with the same letter are not significantly different

Increase in primary branches by 6.5 was observed with KIONZA, showing a positive response to irrigation, compared to rain fed condition. The mean and range at both locations for primary branches confirmed the range reported by Remanandan (1990) and Egbe and Vange

(2008), who reported a range between 11.6 and 23.06, with a mean of 17.2. Yucel *et al.*, (2006) have also reported a significant interaction between location and genotype in chickpeas. Genotypes ICP 7035B (9.7), ICEAP 00911 (7.7), ICEAP 00068 (5.7) and MZ 2/9 (0.3) responded negatively to irrigation during the Main Crop for secondary branches. Similar results were observed on the same genotypes during Ratoon Crop. KIONZA, ICEAP 00902 and KAT 60/8 responded positively to supplementary irrigation at Kiboko, with an increase of 23.5, 15.3 and 15.0 branches respectively during crop while KAT 60/8 (14.1) and ICEAP 00902 (12.8) were increased during the Ratoon Crop.

3.10.8 POD WIDTH AND LENGTH

The mean genotype performance on pod length and width at both locations and seasons are presented on table 18 and 19 respectively, while mean squares for combined ANOVA are presented in table 13a and 13b. Significant difference among genotypes was observed at KYM during crop and Kiboko during Ratoon Crop at ($P<0.001$) and ($P<0.05$) respectively. No significant interaction was observed between location, season, and genotype, indicating that these two characteristics are determined by genes. At KYM, the mean pod length varied from 6.6cm (ICEAP 00902), to 8.4cm (ICEAP 00068), with a mean of 7.4cm, during crop and 5.3cm (ICEAP 00557) to 8.9cm (ICEAP 00068), with a mean of 7.6cm, during Ratoon Crop, as presented in table 18. At this location, the pods were longer by 0.2cm during the ratoon compared to the Main Crop. While KIONZA pods measured 9.3cm, a 1.9 longer at KYM while at Kiboko, it measured 8.8cm, a 0.8cm longer than the test genotypes. During the Main Crop at Kambi ya Mawe, the pod width ranged from 1.1cm (KAT 60/8) to 1.3cm (ICEAP 00068), with a mean of 1.2cm. KIONZA pods were 0.2cm wider than the means of the test genotypes, as presented in table 19. During the Ratoon Crop, pod width ranged from 0.7cm

(ICEAP 00557) to 1.3cm (MZ 2/9), with a mean of 1.1cm at the same location. At Kiboko, the pod width ranged from 1.1cm (ICEAP 00557) to 1.4cm (MZ 2/9) with a mean of 1.2 during the Main Crop.

Table 18: Mean pod length (cm) at Kiboko and Kambi ya Mawe during the crop and Ratoon Crop-2012-13

		Pod Length (cm)			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	7.26bc	7.9	7.9	7.68b
2	ICEAP 00068	8.41ab	8.9	8.4	9.38a
3	ICEAP 00850	7.17bc	8.5	8.0	8ab
4	ICEAP 00554	7.39bc	6.9	8.0	8.22ab
5	ICEAP 00557	7.95abc	5.3	8.0	8.65ab
6	ICEAP 00540	7.41bd	8.4	8.5	8.75ab
7	KAT 60/8	6.97bc	7.4	7.7	7.72b
8	MTAWAJUNI	7.81abc	8.2	8.0	8.19ab
9	MZ 2/9	7.41bc	7.7	8.2	8.21ab
10	ICEAP 00911	7.01bc	7.0	7.5	7.71b
11	ICEAP 00902	6.61c	7.5	7.4	7.9ab
12	KIONZA	9.33a	N/A	8.8	N/A
MSS-Variety		**1.6*****	**2.869^{NS}**	**0.504^{NS}**	**0.803***
LSD $_{(0.05)}$		**0.8884**	**2.502**	**0.953**	**0.92**
CV%		**6.9**	**19.3**	**7.0**	**6.6**
LSD (0.05) Location		**0.3*****	**0.5***		
LSD (0.05) G x L		**0.9NS**	**1.9NS**		
CV% Location		**6.9**	**14.4**		

*, **, ***, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively.
Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

KIONZA pods were 1.5cm wide, 0.3cm wider than the mean of the test genotypes. During Ratoon Crop, pod width ranged from 1.2cm (KAT 60/8) to 1.4cm (MZ 2/9), with a mean of 1.3cm during Ratoon Crop. At Kiboko, the pod length ranged from 7.4cm (ICEAP 00902) to 8.5cm (ICEAP 00540), with a mean of 8.0cm during the Main Crop and 7.7cm (ICP 7035B) to 9.4cm (ICEAP 00068), with a mean of 8.2cm during Ratoon Crop. Compared to the Main Crop, the pods were 0.2cm longer during the Ratoon Crop. The pods were 0.1cm wider in Kiboko at Main Crop and 0.2cm wider during ratoon, compared to those at Kambi ya Mawe.

In vegetable cowpeas, pod length and width are important components, as they are known to influence the pod weight and the yield in this crop (Nwofia, 2012). All genotypes under this study, had pod length longer than 5.5cm, making them suitable for use as vegetable pigeonpea

Table 19: Mean Width at Kiboko and Kambi ya Mawe during the crop and Ratoon Crops 2012-13

		Pod Width (cm)			
		Kambi Ya Mawe		**Kiboko**	
	Genotype	**Main Crop**	**Ratoon Crop**	**Main Crop**	**Ratoon Crop**
1	ICP 7035B	1.2	1.2	1.267abc	1.227ab
2	ICEAP 00068	1.3	1.3	1.277abc	1.393ab
3	ICEAP 00850	1.1	1.1	1.2bc	1.22ab
4	ICEAP 00554	1.2	1.2	1.197bc	1.313b
5	ICEAP 00557	1.2	0.7	1.133c	1.26ab
6	ICEAP 00540	1.3	1.1	1.233bc	1.28ab
7	KAT 60/8	1.1	1.1	1.23bc	1.207b
8	MTAWAJUNI	1.3	1.3	1.3abc	1.36ab
9	MZ 2/9	1.3	1.3	1.407ab	1.44a
10	ICEAP 00911	1.1	1.1	1.193ab	1.22ab
11	ICEAP 00902	1.1	1.1	1.233ab	1.253ab
12	KIONZA	1.4	N/A	1.5a	N/A
MSS-Variety		**0.025***	**0.072^{NS}**	**0.030****	**0.019****
LSD $_{(0.05)}$		**0.172**	**0.361**	**0.152**	**0.128**
CV%		**8.3**	**18.7**	**7.1**	**5.8**
LSD (0.05) Location		**0.01***	**0.1*****		
LSD (0.05) G x L		**0.2NS**	**0.3NS**		
CV% Location		**8**	**13**		

*, **, ***, NS significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ and Non-Significant respectively.
Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

3.11 CORRELATION ANALYSIS

3.11.1 EFFECT OF TEMPERATURE ON YIELD COMPONENTS

Mean temperature during vegetative phase under rain fed condition was positively, and significantly correlated with DTF (0.929), DTM (0.948), Plant Height (0.855), Pod length

(0.716), pod width (0.489), 100 seed mass (0.599) and seed per pod (0.831), but negatively and significantly correlated with shelling percent (-0.518), as presented in Table 20a and 20b. Under supplementary irrigation, there was no significant correlation between mean temperatures during vegetative phase all the yield variables. At flowering phase, DTF (-0.683/-0.871), DTM (-0.722/-0.881), 100 seed mass (-0.528/-0.645) and seed per pod (-0.655/-0.509) were negatively and significantly correlated with mean temperatures at KYM and Kiboko respectively. While only plant height (-0.6920, secondary (-0.598) and primary branches (-0.584) were negatively and significantly correlated with mean temperature at flowering under supplementary irrigation, Pod length (-0.492) was only negatively and significantly correlated with mean temperature under rain fed condition. Mean temperature was negatively correlated with DTF, DTM, Pod length, Pod width, 100 seed mass and seed per pod during podding phase at both location. Plant height, primary and secondary branches were only affected under supplementary irrigation, while shelling percent was positively (0.516) and significantly affected under rain fed conditions. During the Ratoon Crop, mean temperature was negatively correlated with pod length (-0.393) and pods per plant (-0.363) and 100 seed mass (-0.456). Increase in temperature during vegetative phase, under rain fed conditions has a positive influence on duration to flowering and maturity, plant height, shelling percent, pod length, seed per pod, and seed mass. During flowering phase, increase in temperature has a negative influence on yield variables in both location, with the most effect being felt under rain fed conditions, with the following variables being affected: duration to flower, mature, seed mass and seed per pod, while under supplementary irrigation: duration to flower and mature, plant height, pod width, branching, 100 seed weight and seed per pod. Generally, vegetable pigeon pea is negatively affected by increase in temperature during flowering and podding phases of pigeonpea growth and development. The greatest effect is felt under rain fed condition, especially during vegetative growth phase, when yield parameters are accelerated significantly. Increase in mean temperature during the flowering and podding phases significantly affect most of the yield variables under rain fed conditions, than under supplementary irrigation. Increase in mean temperature, during the flowering phases in vegetable pigeonpea growth, under both rain fed and supplementary irrigation, leads to reduction in duration to flowering and maturity, reduced yields, indirectly due to reduced 100 seed mass and plant height. This is supported by Prasad *et al.*, (2003) who observed that decreased number of fruit set at higher temperature was mainly due to poor pollen viability, reduced pollen production, and poor pollen tube growth, all of which leads to poor fertilization of flowers in peanuts. Wang *et al.*, (2006) associated grain yield reduction to reduced pollen viability, reduced number of seeds per plant and weight per seed in chickpeas.

3.11.2 GRAIN YIELD AND YIELD COMPONENTS

Under rain fed conditions (at KYM), grain yield was positively and significantly correlated to pod + grain (0.972), pods per plant (0.345) and shelling percent (0.410) during the Main Crop, as presented in Table 22 and was significantly and positively correlated to plant height (0.522), and pod + grain (0.970) during the Ratoon Crop, as presented in table 24. Under supplementary conditions, grain yield was only positively and significantly correlated to pods per plant (0.325) and pods + Grain (0.926), during Main Crop, as presented in table 21, while during Ratoon Crop, grain yield was only significantly and positively correlated to pods + grain (0.865) and shelling percent (0.564) as presented in table 23. The significant positive correlations between seed yield and number of pods per plant indicates the number of pods a useful criterion for selection of grain yield in vegetable pigeonpea genotypes. Positive and significant correlation between pod per plant and grain yield have been reported by Berhe *et al.*, (1998), and Ulukran, (2003) in faba beans. Plant height positively influenced yields at KYM during ratoon. It could be postulated that with increase plant height the number of pods per plant was increased during ratoon. The study reported a negative association between seed per pod and pods per plant. Similar results have been reported by Yorgancilar *et al.*, (2001) on buch beans varieties.

3.11.3 PODS PER PLANT

Pods per plant were negatively and significantly correlated to 100 seed mass (-0.439) and mean temperature during the Ratoon Crop ($P<0.05$), at Kiboko under supplementary irrigation (Table 23). Under rain fed conditions at Kambi Ya Mawe, pods per plant were positively and significantly ($P<0.05$) correlated with 100 seed mass (0.368) and shelling percent (0.536) (Table 24). Pods per plant was positively and significantly ($P<0.05$) correlated to grain yields at Kiboko (0.325) and Kambi ya Mawe (0.345), during both seasons (Table 21, 22, 23 and 24). The significant and positive association between number of pods per plant and grain yield in this study, indicates that it's a major yield contributing characters in vegetable pigeonpea. Significant and positive correlation between the number of pod per plant and seed yield have been reported by Kumar and Hirochika (2001) on Cowpeas, Sawargoankar *et al.*, (2011), Baskaran and Muthiah (2007), Delighani *et al.*, (2006) and Kamel and Abass, (2012) on Chickpeas and Husain *et al.*, (1988) on field peas. The negative correlation between yield and pods per plant at Kambi ya Mawe, during the ratoon crop could be due to low soil moisture content, leading to abortion of the ovules. This shows that production of greater number of pods per plant under rain fed environment, when the rains and temperatures are low, would not guarantee high seed yield as most pods could be without seed.

Table 20: Correlation coefficient for mean temperatures and yield variables at different growth phases for vegetable Pigeonpeas grown at Kambi ya Mawe and Kiboko in Eastern Kenya-2012/13

Locations	Growth Phases	Days to Flower	Days to 75% Mature	Grain Weight	Plant Height	Pod+ Grain	Pod Length	Pod per Plant
KYM	Vegetative	0.929***	0.9476***	-0.1632	0.8548***	-0.0833	0.7164***	0.1885
KYM	Flowering	-0.6829***	-0.7222***	-0.0272	-0.5748	-0.0423	-0.4915**	-0.2952
KYM	Podding	-0.9789***	-0.9872***	0.2252	-0.8742	0.1444	-0.6501***	-0.1741
KYM	Ratoon	-	-	-0.11	0.0561	-0.0685	0.2922	0.1292
KIBOKO	Vegetative	0.13	0.183	0.123	0.011	0.072	0.133	-0.033
KIBOKO	Flowering	-0.8708***	-0.8806***	0.131	-0.691***	0.147	-0.316	-0.065
KIBOKO	Podding	-0.9818***	-0.9909***	0.175	-0.844***	0.14	-0.3894*	0.023
KIBOKO	Ratoon	-	-	0.108	-0.2786	-0.0469	-0.3931*	-0.362*

KYM: Kambi ya Mawe*, **, ***, NS significant at P <0.05, P< 0.01, and P < 0.001 and Non-Significant respectively.

Table 20b: Correlation coefficient for mean temperatures and yield variables at different growth phases for vegetable Pigeonpeas grown at Kambi ya Mawe and Kiboko in Eastern Kenya-2012/13

Locations	Growth Phases	Pod width	Primary Branches	Secondary Branches	100 Seed Mass	Seed per Pod	Shelling percent
KYM	Vegetative	0.4894**	0.2767	0.0578	0.5999***	0.8305***	-0.518***
KYM	Flowering	-0.2522	-0.1853	-0.1025	-0.528***	-0.6551***	0.1593
KYM	Podding	-0.4229*	-0.2685	-0.0114	-0.5631***	-0.8652***	0.5157***
KYM	Ratoon	0.0745	0.1156	0.0743	-0.4556**	0.2795	-0.0315
KIBOKO	Vegetative	0.291	0.064	0.113	0.085	-0.118	0.063
KIBOKO	Flowering	-0.5796***	-0.5838***	-0.5982***	-0.6453***	-0.5089**	-0.019
KIBOKO	Podding	-0.5693***	-0.6446***	-0.5198***	-0.6873***	-0.6507***	0.082
KIBOKO	Ratoon	-0.1747	-0.0849	-0.0148	0.131	0.1248	0.2673

KYM: Kambi ya Mawe*, **, ***, NS significant at P <0.05, P< 0.01, and P < 0.001 and Non-Significant respectively.

Table 21: Correlation coefficients for the relationship between yield and yield components in Fresh Vegetable Pigeonpeas at KIBOKO during the Main Crop in 2012/2013

	Days to Flower	Days to 75% Mature	Grain Weight	Plant Height	Pod+ Grain	Pod Length	Pod per Plant	Pod width	Primary Branches	Secondary Branches	100 Seed Mass	Seed per Pod	Shelling %
Days to 75% Mature	0.9834***	-											
Grain Weight	-0.171	-0.171	-										
Plant Height	0.8798***	0.8449***	-0.124	-									
Pod+ Grain	-0.113	-0.122	0.9263***	-0.058	-								
Pod Length	0.435**	0.4007*	0.139	0.4974**	0.215	-							
Pod per Plant	-0.062	-0.046	0.3245*	-0.021	0.294	-0.139	-						
Pod width	0.5558***	0.5597***	0.283	0.323	0.308	0.249	0.228	-					
Primary Branches	0.6604***	0.6463***	-0.263	0.6526***	-0.264	0.178	-0.006	0.133	-				
Secondary Branches	0.4909**	0.494*	-0.181	0.449**	-0.3298*	0.036	0.128	0.078	0.6062***	-			
100 Seed Mass	0.6822***	0.678***	0.239	0.5161**	0.3305*	0.4655**	0.037	0.744***	0.139	0.078	-		
Seed per Pod	0.6976***	0.6662***	-0.196	0.7048***	-0.124	0.4878**	-0.021	0.243	0.5596***	0.4173*	0.3902*	-	
Shelling %	-0.140	-0.112	0.222	-0.158	-0.150	-0.159	0.065	-0.054	-0.051	0.3444*	-0.164	-0.146	-
Mean Temp (Vegetative)	0.130	0.183	0.123	0.011	0.072	0.133	-0.033	0.291	0.064	0.113	0.085	-0.118	0.063
Mean Temp (Podding)	-0.9818***	-0.9909***	0.175	-0.8442***	0.140	-0.3894*	0.023	-0.5693***	-0.6446***	-0.5198***	-0.6873***	-0.6507***	0.082
Mean Temp (Flowering)	-0.8708***	-0.8806***	0.131	-0.6918***	0.147	-0.316	-0.065	-0.5796***	-0.5838***	-0.5982***	-0.6453***	-0.5089**	-0.019

*, **, ***, NS significant at P <0.05, P< 0.01, and P < 0.001 and Non-Significant respectively.

Table 22: Correlation coefficients for the relationship between yield and yield components in Fresh Vegetable Pigeonpeas at Kambi ya Mawe during the Main Crop in 2012/2013

	Days to Flower	Days to 75% Mature	Grain Weight	Plant Height	Pod+ Grain	Pod Length	Pod per Plant	Pod width	Primary Branches	Secondary Branches	100 Seed Mass	Seed per Pod	Shelling %
Days to 75% Mature	0.9875***	-											
Grain Weight	-0.2596	-0.2509	-										
Plant Height	0.8907***	0.8822***	-0.1223	-									
Pod+ Grain	-0.168	-0.1664	0.9716***	-0.0478	-								
Pod Length	0.6121***	0.6423***	0.0127	0.7098***	0.07	-							
Pod per Plant	0.1705	0.1847	0.345*	0.1227	0.3215	-0.0304	-						
Pod width	0.4114*	0.4264**	0.1529	0.4041*	0.2397	0.5464***	-0.112	-					
Primary Branches	0.2598	0.2263	-0.0106	0.1428	0.0528	-0.0697	0.2537	-0.0169	-				
Secondary Branches	-0.0315	-0.0369	0.163	-0.1266	0.23	-0.1122	0.3893	-0.1728	0.649***	-			
100 Seed Mass	0.5052**	0.545***	0.3204	0.5089**	0.3379*	0.5164**	0.3068	0.5412***	0.2131	-0.0027	-		
Seed per Pod	0.8525***	0.8534***	-0.2619	0.8272***	-0.1903	0.5169**	0.2707	0.254	0.3143	0.0757	0.4179*	-	
Shelling %	-0.5175**	-0.5077**	0.4102*	-0.4635***	0.2086	-0.3712*	0.248	-0.3353*	-0.3195	-0.2456	-0.1007	-0.484**	-
Mean Temp (Vegetative)	0.929***	0.9476***	-0.1632	0.8548***	-0.0833	0.7164***	0.1885	0.4894**	0.2767	0.0578	0.5999***	0.8305***	-0.5181***
Mean Temp (Podding)	-0.9789***	-0.9872***	0.2252	-0.8742	0.1444	-0.6501***	-0.1741	-0.4229*	-0.2685	-0.0114	-0.5631***	-0.8652***	0.5157***
Mean Temp (Flowering)	-0.6829***	-0.7222***	-0.0272	-0.5748	-0.0423	-0.4915**	-0.2952	-0.2522	-0.1853	-0.1025	-0.528***	-0.6551***	0.1593

*, **, ***, NS significant at P <0.05, P< 0.01, and P < 0.001 and Non-Significant respectively.

Table 23: Correlation coefficients for pair wise comparison of the relationship between yield and yield components in Fresh Vegetable Pigeonpeas at Kiboko during the Ratoon Crop in 2012/2013

Variable	Grain Yield	Mean Temp	Plant Height	Pods + Grain	Pod length	Pods per Plant	Pod width	Primary Branches	Secondary Branches	100 Seed Mass	Seed Per Pod
Grain Yield	1.000										
Mean Temperature	0.108	1.000									
Plant Height	0.018	-0.279	1.000								
Pods + Grain	0.8651***	-0.047	0.178	1.000							
Pod length	-0.196	-0.3931*	0.145	-0.166	1.000						
Pods per Plant	0.189	-0.3627*	-0.045	0.327	0.061	1.000					
Pod width	-0.041	-0.175	-0.012	-0.081	0.219	-0.168	1.000				
Primary Branches	-0.054	-0.085	0.236	-0.034	0.175	0.168	-0.5069**	1.000			
Secondary Branches	0.318	-0.015	0.147	0.178	0.034	0.239	-0.4818**	0.5688***	1.000		
100 Seed Mass	0.084	0.131	-0.096	0.081	-0.106	-0.4388*	0.4801*	-0.4216*	-0.5484***	1.000	
Seed Per Pod	-0.334	0.125	0.031	-0.233	0.118	0.138	0.058	-0.036	-0.227	-0.3819*	1.000
Shelling %	0.5636***	0.267	-0.264	0.083	-0.087	-0.137	0.011	-0.025	0.3552*	0.034	-0.309

, **, *, NS significant at P <0.05, P< 0.01, and P < 0.001 and Non-Significant respectively.*

Table 24: Correlation coefficients for pair wise comparison of the relationship between yield and yield components in Fresh Vegetable Pigeonpeas at Kambi ya Mawe during the Ratoon Crop in 2012/2013

Variable	Grain Yield	Mean Temp	Plant Height	Pods + Grain	Pod length	Pods per Plant	Pod width	Primary Branches	Seco Branches	100 Seed Mass	Seed Per Pod
Grain Yield	1.000										
Mean Temperature	-0.110	1.000									
Plant Height	0.5217**	0.056	1.000								
Pods + Grain	0.9703***	-0.069	0.5558***	1.000							
Pod length	-0.095	0.292	-0.153	-0.146	1.000						
Pods per Plant	-0.026	0.129	-0.172	-0.147	0.077	1.000					
Pod width	0.167	0.075	-0.051	0.116	0.8148***	0.102	1.000				
Primary Branches	0.197	0.116	0.055	0.219	-0.084	-0.009	0.031	1.000			
Secondary Branches	0.061	0.074	0.236	0.130	-0.043	-0.353	0.126	0.6648***	1.000		
100 Seed Mass	0.254	-0.4556**	-0.282	0.102	0.176	0.3682*	0.3711*	0.127	-0.130	1.000	
Seed Per Pod	-0.124	0.280	-0.075	-0.139	0.7199***	0.220	0.6287***	-0.181	-0.114	-0.008	1.000
Shelling %	0.191	-0.032	-0.069	-0.031	0.167	0.5356***	0.219	-0.138	-0.284	0.5134**	0.027

*, **, ***, NS significant at P <0.05, P<0.01, and P < 0.001 and Non-Significant respectively.

Reduced number of pods per plant under rain-fed condition was explained by Saritha *et al.*, (2012), to be due to flower abortion during main flowering and pod abortion during period of rapid development after flowering. Low moisture content in the soil, due to drought, affects anthesis stage causing a drastic reduction in yield and yield components (Seghatoleslami *et al.*, 2008). They postulate that yield reduction is due to drop in number of pods per plant, number of seed per pod and seed weight. Saleem *et al.*, (2005), also reported a high significance difference in pods per plant in Chickpea genotypes as a result of irrigation.

3.11.4 DURATION TO FLOWER AND MATURITY

Under rain fed at Kambi ya Mawe, duration to flower was positively and significantly correlated to duration to maturity (0.988), plant height (0.891), pod length (0.612), and width (0.411), 100 seed mass (0.505) and seed per pods (0.853) as presented in Table 22. Duration to maturity was significantly and positively correlated to duration to flower (0.988), plant height (0.882), pod length (0.642), and width (0.426), 100 seed mass (0.545). Under supplementary irrigation, Duration to flower was positively and significantly correlated to duration to mature (0.983), Plant height (0.879), Pod length (0.435) and width (0.556), Primary branches (0.660), secondary branches (0.491), 100 seed mass (0.682), Seed per pod (0.698) (Table 21). Duration to maturity, was positively and significantly correlated to duration to flower (0.983), plant height (0.845), pod width (0.559) and length (0.401), primary (0.646) and secondary branches (0.494), 100 seed mass (0.678) and seed per pod (0.666).

Genotypes that flowered early, like KAT 60/8, also mature early at both locations. Egbe and Vange (2008) studied the relationship between duration to flower and maturity in pigeonpeas and observed that duration to flowering and maturity are very highly and positively correlated. In fact, Upadhyaya *et al.*, (2006a) indicated that one can confidently predict, the DTM by using DTF of a genotypes. Other studies by Saleem *et al.*, (2005), Yucel *et al.*, (2006) on Chickpeas and Sreelakshmi *et al.*, (2010), Vijayalakshmi *et al.*, (2013), Sodavadiya *et al.*, (2009) on pigeonpeas, have reported a significant positive correlation between duration to flower/maturity and Plant height, Pod length/width, Primary/secondary branches, 100 seed mass and Seed per pod. Delayed flowering and maturity led to improved seed mass at Kiboko by 26.5gms/100 seeds. The local genotype (KIONZA), recorded a high seed mass of 31gms and 27gms at Kiboko and KYM respectively, due to delayed maturity. Sreelakshmi *et al.*, (2010) observed that the high seed mass in late maturing pigeonpea genotypes was because of more reproductive period available for greater duration for seed filling resulting in bolder seeds.

3.11.5 SEED WEIGHT (g/100 Seeds)

100 seed mass was positively and significantly correlated to vegetable grain yields at both locations, with Kiboko recording 0.239 and KYM (0.320), during the Main Crop (Table 21 and 22). Same observation, though not significant, was recorded during Ratoon Crop with Kiboko (0.084) and Kambi ya Mawe (0.254), as presented in table 23 and 24. Ziska *et al.*, (2001) and Thagana *et al.*, (2013) reported a positive correlation between seed mass and seed yield in Soya beans, and Dixit (2005) in lentils. The high seed mass at Kiboko could have been as a result of high mean temperatures of 24°C, compared to that of 23°C at KYM and longer seed filling duration at Kiboko. Patel and Mehta (2001) reported that high mean temperatures favors pod growth and increased seed size and ultimately contributed to increased yield.

3.11.6 SHELLING PERCENT

Shelling percent was negatively and significantly correlated to DTF (-0.518), DTM (-0.508), Plant height (-0.464), pod length (-0.371) and width (-0.335), and seed per pod (-0.484), under rain fed conditions at Kambi ya Mawe (Table 22). Positive correlations was observed during ratoon at Kiboko with grain weight (0.564) and secondary branches (0.355) and at KYM with pods per plant (0.536) and 100 seed mass (0.513) as presented in table 23 and 24.

3.11.7 SEED PER POD

Seed per pod was significantly and positively correlated to DTF (0.698/0.853), DTM (0.666/0.853), plant height (0.705/0.827), pod length (0.488/0.517), primary (0.559) and secondary branches (0.417) and 100 seed mass (0.390/0.417) under supplementary irrigation and rain fed at Kambi ya Mawe respectively, during the Main Crop (Table 21 and 22). During the Ratoon Crop, seed per pod was negatively correlated to 100 seed mass (-0.382), while at KYM, it was positively correlated to pod length (0.719) and pod width (0.628) as presented in table 23 and 24.

3.11.8 BRANCHING

Primary branches were positively and significantly correlated to secondary branches (0.606) and seed per pod (0.559) during Main Crop, under supplementary irrigation as presented in table 21. Secondary branches were also positively correlated to seed per pod (0.417) and shelling percentage (0.344) during the Main Crop, under supplementary irrigation (Table 21). During the Ratoon Crop, primary branches were positively correlated to secondary branches (0.569) and negatively correlated to 100 seed weight (-0.422). Secondary branches were also negatively correlated to 100 seed mass (-0.382) during the Ratoon Crop (Table 23). A positive and significant correlation between primary/secondary branches and duration to flower/Maturity and with plant height, seed per pod and shelling percent, was observed under supplementary irrigation during the Main Crop (Table 21). Primary branches were positively and significantly to plant height and seed per pod at Kiboko, secondary branches at Kambi ya Mawe during the ratoon (Table 24). Positive correlation between plant height and branching was observed in this study. KIONZA, a local genotype which recorded the longest height, above 200m, also recorded higher number of branches, at both locations. Positive and significant correlations between branches with plant height have also been reported by Vijayalakshami *et al.,* (2013). Both primary and secondary branches were also positively linked with seed weight and seeds/pod, at both locations during the Main Crop. This indicates that under favorable conditions, high number of branches translates to increased seed weight and seed per pod. Same results have also been reported by Bharathi and Saxena (2013) and Saleem *et al.,* (2005). Significant interaction between branching and location confirms Dawkins *et al.,* (1984) findings, who observed that branching in vining peas, is strongly influenced by environmental conditions such as soil physical conditions or soil water status.

3.11.9 POD LENGTH AND WIDTH

While Pod length was positively and significantly correlated to pod width (0.564), 100 seed mass (0.516) and seed per pod (0.517), it was negatively and significantly correlated to shelling percent (-0.371) and flowering (-0.492) during Main Crop at KYM, as presented in table 22. During the Ratoon Crop, pod length was positively and significantly correlated to pod width (0.815), seed per pod (0.719), while pod width was positively correlated to 100 seed mass (0.3771) and seed per pod (0.629) as presented in table 24. Under supplementary irrigation, pod length was positively and significantly correlated to 100 seed mass (0.466) and seed per pod (0.488), pod width was only positively and significantly correlated to 100 seed weight (0.744) during Main Crop (Table 21). During the Ratoon Crop, pod width was negatively correlated to primary (-0.507), secondary (-0.482) branches, it was positively correlated to 100 seed mass (0.480) (Table 23). A strong positive correlation was observed between seed mass and pod length/width at both locations. This study has shown that long pods produces large seeds and high number of seeds per pod. While breeding for vegetable pigeonpeas, long pod size is the most important characteristic for vegetable pigeonpea and genotypes with more than 5.5cm mean is considered for selection (Saxena, *et al.*, 2010a), Saxena and Sharma (1990), Faris *et al.*, (1987), Saxena *et al.*, (2010b).

3.11.10 PLANT HEIGHT

At Kiboko, under supplementary irrigation, plant height was negatively correlated to grain yields during the Main Crop at both locations (-0.124 at KYM and -0.122 at Kiboko) but positively correlated, though not significant during the Ratoon Crop (0.018 at KYM and 0.523 at Kiboko), as presented in table 21 and 22. Under rain fed conditions, Plant height was positively and significantly correlated to pod length (0.709), 100 seed mass (0.509), and seed per pod (0.827) and pod width (0.404), during Ratoon Crop (Table 24). While under supplementary condition, plant height was significantly and positively correlated with pod length (0.497), primary (0.653) and secondary (0.449) branches, 100 seed mass (0.516) and seed per pod (0.705), during the Ratoon Crop (Table 23). The positive correlation between plant height and crop yield during the Ratoon Crop could be as a result of increase in number of leaves and production of more branches, leading to more pods being produced. According to Udensi *et al.*, (2010) these traits (plant height, leaves, and branches) seem to be functioning in tandem with one another in Soya beans. Their facilitator role contributes significantly to final yield and should be considered during selection to improve yield in breeding programme.

CHAPTER FOUR: VEGETABLE PIGEONPEA GENOTYPE PREFERENCE AND ACCEPTABILITY

4.1 INTRODUCTION

Pigeonpea is mainly cultivated by smallholder farmers in the arid and semi-arid lands, primarily as a source of food, nutrition and income (Mergeai *et al.*, 2001a). It is consumed in many forms though mostly as a complement in cereal-based diets in many parts of Kenya particularly in the Eastern, Central, and Coastal regions (Kimani *et al*, 1994). Besides its nutritional value, Pigeonpeas also possesses various medicinal properties due to the presence of a number of polyphenols and flavonoids (Saxena *et al.*, 2010c). Cultivars for vegetable pigeonpeas are grown as a normal field crop, but the pods are harvested at the appropriate stage of maturity for use as vegetable pigeonpea (Singh *et al.*, 1984). Those sold in the domestic market is either shelled manually before selling to consumers in small volumes, or sold in-shell depending on the target retail market (Shiferaw, *et al.*, 2008). Quality requirements in the domestic vegetable pigeonpea markets are limited to physical attributes, which are assessed through physical inspection (Shiferaw, *et al.*, 2008).

Previous analysis of consumer demand for legumes focused on visible characteristics of raw seeds (Mkanda *et al*, 2007). Visible characteristics of raw seeds, however, are not a reliable measure for cooking quality. Legumes with similar appearance may have significantly different cooking properties. Growing location has been reported to affect the cooking quality of legumes by changing their structure and texture (Yueng, 2007). Climate, soil type, moisture, and other factors interact with genetic factors to produce cowpeas of varying cooking and organoleptic quality (Yeung, 2007). In a study reported by Iliadis (2003), long cooking lentil varieties significantly differed in their cooking times when grown in different soil types, while short cooking varieties did not significantly differ. He concluded that genotype affected cooking time variations more than environmental conditions. Human sensory data provide a better model of how consumers will react to food products than instrumental data as these data take into account both the product properties and the interpretation of these properties by consumers (Lawless and Heymann, 2010). As improved Pigeonpeas genotypes are developed to overcome the challenges of biotic and achieve the goal for higher yields, consumer acceptability in pigeonpea products must be considered at an earlier stage in the breeding process, to increase adoption.

There is limited systematic information on the description of sensory properties that differentiate vegetable pigeonpea genotypes, currently being grown by farmers in the Eastern region of Kenya, in terms of liked or disliked, based on taste, appearance, aroma, texture flavor and texture. The objective of this study was to determine the acceptability and preference of vegetable medium duration Pigeonpea genotypes among the farmers and consumers, using sensory characteristics in the Eastern region of Kenya.

4.2 STUDY SITES

The study was carried out at the Kenya Agriculture and Livestock Research organization (KALRO) Kiboko station and Kambi Ya Mawe (KYM) sub-station between October 2012 and August 2013, under supplementary irrigation and rain fed field experiments, respectively, as explained in chapter 3.

4.3 PIGEONPEA GENOTYPE

Twelve medium duration pigeonpea genotypes (ICP 7035B, ICEAP 00068, MTHAWAJUNI, MZ 2/9, KAT 60/8, ICEAP 00540, ICEAP 00557, ICEAP 00911, ICEAP 00902, ICEAP

00554, ICEAP 00850 and KIONZA) were tested in this study. The physical characteristics of these genotypes are presented in Table 25 below. KIONZA, a local genotype, being adopted by many farmers in the region, for both grain and green vegetable pea, due to its earliness, was used as control in this study. The name, KIONZA, is derived from the seven seed characteristic, in local dialect.

Table 25: Vegetable pigeonpea genotype characteristics based on fresh seed color and seed mass (g/100 seeds)

			Seed Weight (g/100 seeds)	
	Genotype	**Seed Color**	**KYM[y]**	**KIB[z]**
1	ICP 7035B	Brown/Bronze and Speckled	25.2	25.8
2	ICEAP 00068	Green	24.9	26.2
3	ICEAP 00850	Light Green	21.5	24.6
4	ICEAP 00554	Green	21.0	25.5
5	ICEAP 00557	Green	23.1	25.9
6	ICEAP 00540	Green	22.9	24.9
7	KAT 60/8	Pale Green	21.3	23.9
8	MTHAWAJUNI	Dark purple and speckled	28.8	30.4
9	MZ 2/9	Dark Brown/Bronze	35.9	35.6
10	ICEAP 00911	Pale Green	21.8	24.8
11	ICEAP 00902	Pale Green	23.8	23.9
12	KIONZA	Green with brown ringed Helium	24.6	26.5
	Mean Seed Weight[x]		**24.6**	**26.5**

[x] Seed weight was quantified on 100 seeds randomly sampled, counted and weighed.

[y] *KYM: Kambi ya Mawe;* [z] *KIB: Kiboko*

4.4 METHODOLOGY

This study used acceptance testing method to evaluate acceptability among farmers and panelist, from the Department of Food Science and Nutrition, University of Nairobi. The method is used to determine whether the consumer accepts the product being developed or not. This test is usually performed with the nine or seven point hedonic scale (Carpenter, Lyon, and Hasdell, 2000). Several studies have used the same method. Resureccion (2004) used acceptance testing to determine consumer choices for meat and meat products. Platter, Tatum, Belk, Chapman, Scanga, and Smith (2003) used a hedonic scale to evaluate tenderness and juiciness of steak.

4.5 PANELIST SELECTION AND TRAINING

Consumers consisting of Women farmer, who are already involved in growing of vegetable pigeon pea, and prepare them at household level, were drawn from Kwagathoga village, located near the Kambi ya Mawe research station, were mobilized, a week to the actual testing of the crop samples, in the month of February, 2013. On the actual day, a group of fifteen women aged between 25 to 56 years, were recruited for the acceptability studies as respondents. Preliminary screening was done based on acquaintance with the desired sensory attributes of vegetable Pigeon peas, they are regular consumers of fresh Pigeonpeas and not allergic to any food, following procedure outlined in Meilgaard, *et al* (2007). All the selected consumer panelists qualified for the actual test after the initial screening. The team was then trained, on the sensory attributes of vegetable pigeonpeas and use of appropriate descriptive terms in round table discussions, before the testing began and supervised by the panel leader. Mock sensory testing, involving three genotype, of different in color, seed size and taste were presented to the panelists. Finally, 10 panelists were selected.

Same participant were called upon to participate in the subsequent evaluation, during the Ratoon Crop, in the month of July, 2013. A preset questionnaire was used during both evaluations, as presented in appendix 1. Acceptance evaluation test, based on sensory attributes, was also carried out by a group of panelists from the Department of Food Science and Nutrition, who were mobilized for evaluation in the month of July, 2013, a week before evaluation. On the day for evaluation, thirteen staff responded (5 male and 8 female). Sensory testing, involving three genotype, different in color, seed size and taste was presented to the team, as a mock test, for selection of the final team. Seven panelists (2 male and 5 female), were ultimately selected to participate in the evaluation. The selection was based on how well they understood the process, and how accurately they filled the questionnaire, presented in appendix 1. They were aged 25-47 years, and not allergic to any food.

4.6 SAMPLE PREPARATION

Fresh pods from each plot were harvested and shelled early in the morning for evaluation with women farmer consumer panelists from Makueni, and late in the evening for evaluation with panelists, because it required transportation to Nairobi early in the Morning. Fresh pods were harvested separately from both locations, threshed by a team of casuals. The samples from the three replicates, were thoroughly mixed and a sample of 200grams taken, per genotype, per location. The sample for laboratory sensory evaluation were packed in a cool box, with ice, the previous day in the evening, based on recommendation by Onyango and Silim (2000) who observed that low temperature storage extends the shelf life of vegetable pigeonpeas, and concluded that low temperature storage (4±1°C) minimizes loss of nutrients such as sugars and protein and more loss of TTA hence may be adopted during postharvest handling of vegetable pigeonpeas. The samples were then transported early in the morning from Kiboko, reaching the laboratory, by 6.30am.

During evaluation with women farmer's panelists in Makueni, three women, experienced in cooking vegetable pigeonpeas were engaged, to cook, using a gas cooker, to the required softness, by an experienced cook, well averse in cooking green peas, was engaged for the activity. The sample were cooked to a status normally softness, done at the household, to match the consumer expectation of what is regarded as a cooked product, by chewing, seeds using the molars and then compressed against the palate with the tongue to evaluate particle size as explained by Fasoyiro *et al.,* (2005).

The procedures used at the preparation of products and product presentation was carefully selected and monitored. Efforts to reduce potential biases were made; the serving plates used was checked not to transferring any aroma or flavor to the product, and efforts to get all samples served at the same temperature and in equal amounts was done. The testing was done in an excluded area at the station with farmers, free from strong winds. The test by panelists was carried out in a laboratory environment, free from interference.

4.7 SENSORY EVALUATION

Sensory evaluation was carried out three times. First with 10 women farmer panelists during the Main Crop in Makueni. They evaluated 11 genotypes, as the local genotype (KIONZA) had was not yet ready. The second evaluation was done again with 10 women farmer's panelists in Makueni during the Ratoon Crop, who evaluated 12 genotypes. Thirdly with 7 panelist drawn from the Department of Food Science and Nutrition Laboratory. All samples were served in duplicate (Melgaard *et al., 2007)* and presented to panelists. Testers rinsed their mouth after testing each genotype to reduce the lingering taste of the last tested genotype. Same procedure has been reported by Kwach *et al.,* (2010) in sensory testing of sweet potatoes. The farmer's sensory was done by the same panel members, during both main crop and Ratoon Crops, thus enabling comparison of all genotypes for both seasons.

4.8 STATISTICAL DATA ANALYSIS

The sensory determination was conducted in duplicate, during all the three times of evaluation. The effect of genotype, growing location and panelist and their interaction was evaluated using analysis of variance (ANOVA), based on a 5 % level of significance using

GENSTAT 14th edition (Payne *et al.*, 2011). The mean values of the genotypes of each parameter were further compared by using the least significant difference (LSD$_{<0.05}$) test at ($P<0.005$) level of probability, using Turkey's method (Ott, 1988). Data normality was determined using a histogram. It's a graphical representation of the output of the frequency function, for discerning whether the data approximates the bell curve of a normal distribution.

4.9 RESULTS AND DISCUSSION

4.9.1 PIGEONPEAS SEED APPEARANCE

The appearance of the cooked vegetable pigeonpeas was evaluated during the main crop and ratoon crop, with farmers and panelists during the ratoon crop. There was significant difference among the genotypes on appearance, as scored by farmers during main and ratoon crop and panelists during the ratoon crop at both locations ($P<0.001$). Locations had a significant effect ($P<0.001$) during crop and ratoon at both locations, and ($P<0.05$) during sensory evaluation with consumers as presented in table 26. Interaction between location and Genotype (L x G) was significant during main crop, ratoon crop and panelists evaluation ($P<0.001$). Seasons had a significant influence on seed appearance at KYM ($P<0.001$) but not significant at Kiboko ($P<0.05$). Interaction between season and genotypes (G x S) was significant at both locations ($P<0.001$), as presented in Table 27. Sensory evaluation during Main Crop gave a mean score of 4.5 at KYM, while at Kiboko, the mean score of 4.2. ICEAP 00554 (5.6), ICEAP 00540 (5.3) and Kat 60/8 (5.2) were the most preferred genotypes at KYM. ICEAP 00554 (5.6) being preferred at Kiboko. Genotypes with brown, speckled colored seeds were not preferred. These show that preference based on appearance in mainly associated with the seed color. Sensory evaluation during ratoon crop for appearance gave a mean of 4.5 at Kambi ya Mawe, while at Kiboko gave a mean of 4.1. ICEAP 00911 (5.6)

ICEAP 00557 (5.6) and Mthawajuni (5.6) were the most preferred at Kambi ya Mawe, while at Kiboko, ICEAP 00068 (5.6), ICEAP 00540 (5.5) and ICEAP 00850 (5.5) were the most preferred.

Table 26: Mean sensory scores for seed appearance with farmers and panelists during main crop and ratoon Crops at KYM^{y} and Kiboko^{y}-2013

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.1cd	3.6abcd	3.8ab	5.6d	6.1ef	4.6ab
ICEAP 00540	5.3d	4.1bcd	5bc	5.5d	5.9ef	3.9a
ICEAP 00554	5.6d	5.6e	5.3c	3.3bc	5.6cdef	5.7bc
ICEAP 00557	4.6bcd	4.6bcde	5.6c	4.8d	4.3abc	6.1c
ICEAP 00850	4.8bcd	4.4bcde	4.5abc	5.5d	3.9ab	4.6abc
ICEAP 00902	4.9cd	4.9de	5.0bc	5.1d	5.1bcdef	4.9abc
ICEAP 00911	3.7b	4.6bcde	5.6c	4.3cd	6.2f	4.1a
ICP 7035 B	2.2a	3.3ab	5.4c	2.4ab	4ab	3.9a
KAT 60/8	5.2d	4.7cde	5.5c	4.9d	5.6def	5.3abc
MTHAWAJUNI	3.9bc	3.5abc	5.6c	4.6cd	3.5a	4.4ab
MZ 2/9	4.6bcd	2.4a	3.4a	2ab	4.9bcde	4.3ab
KIONZA	N/A	N/A	4.3abc	1.8a	4.4abcd	4.6ab
CV% (Genotype)	24.8	31.1	26.8	33.3	21	25.4
LSD$_{(0.05)}$ Genotype (G)	0.7***	0.9***	0.82***	0.86***	0.78***	0.89***
LSD$_{(0.05)}$ Season (S)	0.25	0.28				
LSD$_{(0.05)}$ G x S	0.58	0.64				
CV% (G x S)	27.2	34				
LSD$_{(0.05)}$ Location (L)	0.25***		0.24***		0.25*	
LSD$_{(0.05)}$ G x L	0.84***		0.84***		0.87***	
CV% (G x S)	29.4		29.9		24.3	

*, **, *** significant at, $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ respectively. Means *with the same letter are not significantly different* at the 0.05 probability level by Turkey's test

^{y}Locations in which the agronomic experiments and sensory evaluations were conducted during the cropping cycle and the ratoon season crop.

Sensory evaluation with panelists on appearance gave a range from 3.5 and 6.2, with a mean of 4.9, at Kambi ya Mawe, while at Kiboko achieved a mean of 4.8. ICEAP 00540 (5.9), ICEAP 00068 (6.1) and ICEAP 00911 (6.2) were the most preferred at KYM. At Kiboko, KAT 60/8 (5.3), ICEAP 00554 (5.7) and ICEAP 00557 (6.1) were the most preferred. The most preferred genotypes across the locations were ICEAP 00068 (5.3) and KAT 60/8 (5.5). Seed color has been shown to be the determinate characteristic when selecting vegetable pigeonpea genotypes for preference, with green seeded genotypes such as ICEAP 00554 being most preferred. Brown, speckled or bronze colored genotypes such as MZ 2/9, Mthawajuni, and ICP 7035B scored poorly by both farmers and panelists.

Table 27: Mean squares for interaction between genotype and season for sensory characteristics of vegetable pigeonpeas at KYM and Kiboko- 2013

		Seed appearance[w]		**Seed Colour**		**Odour/Smell**	
Source	**df**	**Kiboko**	**KYM**	**Kiboko**	**KYM**	**Kiboko**	**KYM**
Testers	11	0.43^{NS}	0.53^{NS}	0.125^{NS}	0.02^{NS}	0.020^{NS}	0.05^{NS}
Genotype (G)	11	43.4***	19.1***	41.7***	26.3***	14.63***	6.7***
Season (S)	1	2.14NS	13.5***	10.10*	61.7***	8.96*	28.9***
G x S	10	9.91***	8.14***	13.28***	3.96**	5.93***	4.4*
CV %		34	27.2	35.3	25.8	32.8	32.1

		Taste[x]		**Tenderness**		**Overall Acceptance**	
Source	df	**Kiboko**	**KYM**	**Kiboko**	**KYM**	**Kiboko**	**KYM**
Testers	11	0.31^{NS}	1.23^{NS}	2.19^{NS}	0.52^{NS}	1.717^{NS}	0.25^{NS}
Genotype (G)	11	18.5***	8.69***	11.01***	11.5***	24.1***	12.1***
Season (S)	1	4.95NS	29.1***	11.26*	11.2*	0.28NS	0.29NS
G x S	10	5.19**	6.7***	5.11**	6.78***	7.84***	5.02***
CV %		33.7	32.5	33.1	28.5	29.2	23.7

[w] Visual appeal for seed appearance, color and aroma of vegetable pigeon pea seed as evaluated by a randomly selected and trained sensory evaluation panels consisting of farmers and consumers. Assessment was conducted using hedonic scale of 1-7 where 1= highly unfavorable (dislike) and 7=highly favorable scale (likable).

[x] Evaluation of seed taste and tenderness subsequent to normal cooking of vegetable pigeon pea and its overall acceptability by a trained panel of farmers and consumers based on hedonic scale of 1-7 (highly unfavorable-highly favorable).
The ns=non-significant, * =significant at *P<0.05*; ** = significant at *P<0.01*.

In a sensory study done on green beans by Khan and Arvanitoyannis (2003), they observed that high overall impression of the bean was closely related to color, while Makelo (2011) reported that cream seeded pigeonpea dry grains was an important preference attribute indicated by farmers in Kenya. She concluded that genotypes with these attribute are preferred because of the better economic returns when sold as green pods. Combined analysis indicated that while difference between farmers was not significant, genotype (G), location (L), season (S) (only at KYM), and interaction between G x L and G x S were significant as presented in table 27. This indicates that appearance of genotype is not determined by the genes only, but by environment where the genotype is planted and the season of growth in the region. These two factors interacted to determine the appearance of vegetable pigeonpeas. Similar results have been reported by Yueng (2007) on beans.

4.9.2 PIGEONPEA SEED COLOR

The color of cooked vegetable pigeonpea genotype seeds were evaluated by farmers during the main crop and Ratoon Crop and by consumers during the Ratoon Crop. Genotype were significantly different ($P<0.001$) in terms of seed color as evaluated by farmers and consumers, as presented in table 28. Interaction between location and genotype (L x G) was significant during evaluation with farmers during crop and ratoon and with consumers ($P<0.001$). Location had a significant influence on the seed color of the genotypes during ratoon ($P<0.001$) and with consumers ($P<0.01$), but not significant during Main Crop at ($P<0.05$) (Table 28). Season had a significant effect on the seed color at Kiboko ($P<0.05$) and KYM ($P<0.001$). Interaction between genotype and season (G x S) was also significant at KYM ($P<0.01$) and Kiboko ($P<0.001$), as presented in table 27. Sensory evaluation with farmers during Main Crop indicated a mean score of 4.6 at KYM, while at Kiboko recorded a mean score of 4.4. KAT 60/8 (5.7), ICEAP 00540 (5.7) and ICEAP 00554 (5.3) were the most preferred genotypes at KYM, while ICEAP 00554 (5.6), ICEAP 00902 (5.3) and KAT 60/8 (5.2) were the most preferred at Kiboko. ICEAP 00554 (5.4), ICEAP 00902 (5.3) were the most preferred across the locations. Sensory evaluation with farmers during the Ratoon

Crop indicated a mean acceptance for color of 5.3 at KYM, while at Kiboko, a mean of 4.2 was recorded. ICEAP 00911 (6.1), ICEAP 00557 (6.1) and ICEAP 00554 (5.8) were the most preferred. At Kiboko, ICEAP 00540 (5.8), ICEAP 00850 (5.8) and KAT 60/8 (5.2) were the most preferred, while ICEAP 00850 (5.6), ICEAP 00557 (5.6) and ICEAP 00540 (5.7) were the most preferred across the locations.

Table 28: Mean sensory scores for cooked seed color with farmers and consumers during crop and Ratoon Crops at KYM and Kiboko-2013

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.1de	4.2bcd	5.1b	5de	6.1c	5.3bcd
ICEAP 00540	5.7e	4.8cd	5.6b	5.8e	6.3c	5.1abcd
ICEAP 00554	5.3e	5.6d	5.8b	3.2abc	5.6bc	5.5bcd
ICEAP 00557	4.8cde	4.9cd	6.1b	5.1de	5.4bc	6.1d
ICEAP 00850	4.9cde	4.6cd	5.3b	5.8e	5bc	5.1abcd
ICEAP 00902	5.3de	5.3cd	5.8b	4.1bcd	5.9bc	5.1abcd
ICEAP 00911	3.9bc	4.6cd	6.1b	4.5cde	6.3c	4.3abc
ICP 7035 B	2.1a	3.8bc	5.4b	2.5ab	3.6s	3.6a
KAT 60/8	5.7e	5.2cd	5.5b	5.2de	5.7bc	5.6cd
MTHAWAJUNI	3.5b	2.9ab	5.2b	5de	3.4a	4.1ab
MZ 2/9	4.1bcd	2.2a	3.5a	2.5ab	4.5ab	4.1ab
KIONZA	N/A	N/A	4.8ab	1.9a	5.6bc	4.8abcd
CV% (Genotype)	24	32.6	24.6	36	20.7	23.8
LSD$_{(0.05)}$ Genotype (G)	0.7***	0.9***	0.82***	0.94***	0.81***	0.87***
LSD$_{(0.05)}$ Season (S)	0.25***	0.29*				
LSD$_{(0.05)}$ G x S	0.58**	0.68***				
CV% (G x S)	25.8	35.3				
LSD$_{(0.05)}$ Location (L)	0.26^{NS}		0.26***		0.25**	
LSD$_{(0.05)}$ G x L	0.87***		0.9***		0.85***	
CV% (G x S)	29.7		30.5		22.6	

*, **, *** significant at, $P\leq0.05$, $P\leq0.01$, and $P\leq0.001$ respectively

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

Sensory evaluation with panelists for genotypes planted at Kambi ya Mawe recorded a mean of 5.3, while at Kiboko, a mean of 5.1 was recorded. ICEAP 00068 (6.1), ICEAP 00540 (6.3) and ICEAP 00911 (6.3) were the most preferred at Kambi ya Mawe. At Kiboko, ICEAP 00554 (5.6), KAT 60/8 (5.7) and ICEAP 00557 (5.8) were the most preferred. ICEAP 00068 (5.7), KAT 60/8 (5.7) and ICEAP 00557 (5.8) were the most preferred genotypes across the locations. Combined analysis of variance indicated that location does influence the genotype seed color only during Ratoon Crop. Genotypes also interacted with locations to determine the seed color of vegetable pigeonpeas. Though KIONZA, a local genotype, highly adopted by farmers in the region, due to its earliness, seven seeded pods and large seeds (31 grams/100 seeds), it scored poorly on color, due to a round ring around the helium. The color of vegetable pigeonpea influences their acceptability, and therefore, breeding of improved genotypes should be towards green/light/pale seed coat color. According to Zellner (1991), familiar foods are generally liked more than unfamiliar foods. ICP 7035B, Mthawajuni and MZ 2/9, whose seed color are brown/speckled, are unfamiliar genotypes, which are currently not being commercialized by farmers in large scale in the region. Keith *et al.*, (2004) reported that rural communities in Africa are thought to be cautious about accepting food substantially different in color from those they are used to. Genotypes with brown/bronze colored seeds were therefore rated low, in both cases. In beans, colored seeds are favored by consumers, while others prefer white seeds because they do not tint the color of the cooking water that is often served with the beans (Negri *et al.*, 2001). Mula and Saxena (2010) reported that in pigeonpeas, genotypes with white seed coat, which have a bright green color when harvested as a vegetable, are preferred to ones that are colored because the cooking water in the former remains clear. Latunde-dada (1993) reported that seed coat color of cowpea seed greatly influences the choice and marketability of cowpea genotypes in Nigeria, and observed that the brown coated cowpea genotypes are more favored above the white-coated peas.

Table 29: Mean squares for interaction between genotype and location on sensory characteristics of vegetable pigeon peas genotypes at KYM and Kiboko during crop and Ratoon Crop- 2012/13

		Seed Appearance[w]			Seed Colour (Crop)			Seed Odour/ Smell		
Source	df	Crop	Ratoon	Consumers	Crop	Ratoon	Consumers	Crop	Ratoon	Consumers
Tester	11	17.44^{NS}	9.4^{NS}	8.47^{NS}	15.98^{NS}	19.02^{NS}	5.02^{NS}	16.25^{NS}	15.46^{NS}	5.99^{NS}
Genotype	11	22.67***	30.3***	9.16***	32.88***	32.36***	16.61***	15.19***	7.19***	1.42^{NS}
Location	1	13.46***	68.3***	5.76*	3.84^{NS}	155.3***	11.81**	80.01***	2.41^{NS}	0.19^{NS}
G x L	10	8.69***	20.5***	9.65***	7.87***	14.89***	4.55***	7.34***	3.34^{NS}	6.26***
CV %		29.4	29.9	24.3	29.7	30.5	22.6	26.8	33.7	22.4

		Taste[x]			Tenderness			Overall Acceptance		
Source	**df**	**Crop**	**Ratoon**	**Consumers**	**Crop**	**Ratoon**	**Consumers**	**Crop**	**Ratoon**	**Consumers**
Tester	11	7.35^{NS}	21.55^{NS}	8.07^{NS}	8.23^{NS}	16.63^{NS}	2.52^{NS}	7.61^{NS}	7.29^{NS}	4.57^{NS}
Genotype (G)	11	11.16***	6.80***	1.13^{NS}	12.6***	8.59***	4.56***	15.6***	17.89***	5.97***
Location (L)	1	31.49***	0.17NS	3.24^{NS}	19.56***	18.41**	1.71^{NS}	34.57***	27.55***	7.44**
G x L	10	5.17***	6.15***	6.07***	5.97***	7.27***	11.97***	12.45***	4.31**	6.85***
CV %		30.0	33.7	28.6	28.9	30.7	22.8	21.9	28.2	18.2

[w] Visual appeal for seed appearance, color and aroma of vegetable pigeon pea seed as evaluated by a randomly selected and trained sensory evaluation panels consisting of farmers and consumers. Assessment was conducted using hedonic scale of 1-7 where 1= highly unfavorable (dislike) and 7=highly favourable scale (likable).

[x] Evaluation of seed taste and tenderness subsequent to normal cooking of vegetable pigeon pea and its overall acceptability by a trained panel of farmers and consumers based on hedonic scale of 1-7 (highly unfavourable-highly favourable).
The ns=non-significant, * =significant at *P<0.05*; ** = significant at *P<0.01*.

4.9.3 PIGEONPEA SEED AROMA AND TASTE

4.9.3.1 PIGEONPEA SEED AROMA

The genotypes were significantly different in aroma during Main Crop ($P<0.001$), ratoon crop at KYM ($P<0.05$ and Kiboko ($P<0.001$) and with consumers at KYM ($P<0.001$) and Kiboko ($P<0.01$), as presented in table 30 below.

Table 30: Mean sensory scores for aroma with farmers and consumers during crop and Ratoon Crops at KYM and Kiboko-2013

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.2b	3.3ab	4.7ab	4.6bc	5.7bc	4.9a
ICEAP 00540	4.3ab	3.2ab	4.2ab	4.5abc	5.7bc	4.3a
ICEAP 00554	5.5b	5.3d	4.1ab	4.2abc	4.8abc	5.5a
ICEAP 00557	4.7ab	4.6cd	4.7ab	5c	4.8abc	5.4a
ICEAP 00850	4.7ab	3.8bc	5b	4.5abc	3.9a	5.5a
ICEAP 00902	5.1b	5.2d	3.9ab	4.4abc	4.7abc	5.4a
ICEAP 00911	3.7a	3.6bc	3.7ab	4.1abc	6.1c	4.7a
ICP 7035 B	3.5a	3.1ab	4.3ab	3.6ab	4.5ab	5.3a
KAT 60/8	5.2b	3.6bc	4.1ab	4.2abc	5.1abc	4.2a
MTHAWAJUNI	4.3ab	3.6bc	4.1ab	4abc	4.9abc	4.6a
MZ 2/9	5.1b	2.3a	3.5a	3.1a	5.2abc	5.1a
KIONZA	N/A	N/A	4.8ab	3.3ab	4.9abc	4.9a
CV% (Genotype)	24.1	28.2	33.9	33.8	21.9	21.1
$LSD_{(0.05)\ Genotype\ (G)}$	0.70***	0.70***	0.89*	0.86***	0.82***	0.79**
$LSD_{(0.05)\ Season\ (S)}$	0.28***	0.26*				
$LSD_{(0.05)\ G \times S}$	0.64*	0.58***				
CV% (G x S)	32.1	32.8				
$LSD_{(0.05)\ Location\ (L)}$	0.22***		0.25^{NS}		0.24^{NS}	
$LSD_{(0.05)\ G \times L}$	0.74***		0.87^{NS}		0.83***	
CV% (G x S)	26.8		33.7		22.4	

*, **, *** significant at, $P\leq0.05$, $P\leq0.01$, and $P\leq0.001$ respectively

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

Locations had a significant influence on the aroma of the vegetable pigeonpea seed during main crop ($P<0.001$), but non-significant during the ratoon Crop. Interaction between location and genotype (G x L) was significant during the main crop and ratoon crop ($P<0.001$) (Table 27). There was no significant interaction between G x L for aroma during evaluation of the genotypes with farmers during ratoon Crop at ($P<0.05$). Seasons had a significant influence on aroma at both locations. Interaction between seasons and genotypes (G x S) was also significant at Kiboko ($P<0.001$) and KYM ($P<0.05$).

Sensory evaluation for aroma of vegetable pigeonpea genotype seed scored a mean acceptance of 4.7 at Kambi ya Mawe, during main crop. At Kiboko, the mean of 3.8 was achieved. ICEAP 00554 (5.5), KAT 60/8 (5.2) and ICEAP 00068 (5.2) were the most preferred genotypes at KYM, while at Kiboko, ICEAP 00554 (5.3), ICEAP 00902 (5.2) and ICEAP 00557 (4.6) were the most preferred (Table 30). During ratoon Main Crop, ICEAP 00850 (5.0), KIONZA (4.8) and ICEAP 00557 (4.7) were the most preferred genotypes at Kambi Ya Mawe, while at Kiboko, ICEAP 00577 (5.0), ICEAP 00068 (4.6) and ICEAP 00540 (4.5) were the most preferred. Evaluation by panelists indicated mean score of 5.0, at KYM and 5.0 at Kiboko. ICEAP 00540 (5.7), ICEAP 00068 (5.7) and ICEAP 00911 (6.1) were the most preferred at KYM, while ICEAP 00557 (5.4), ICEAP 00850 (5.5) and ICEAP 00554 (5.5) were the most preferred at Kiboko.

4.9.3.2 PIGEON PEA COOKED SEED TASTE

Acceptance evaluation of the genotype for vegetable pigeonpea seed for taste indicated a significant difference at both locations during crop and ratoon, but non-significant during evaluation by panelists at KYM, as presented in table 31 below. Genotype were significantly different during the evaluation by panelists for Kiboko products ($P<0.01$) (Table 31). While seasons had a significant influence on genotypes in terms of taste at KYM ($P<0.001$), it didn't have an effect at Kiboko at ($P<0.05$). Interaction between genotype and season (G x S) was significant at Kiboko ($P<0.01$) and KYM ($P<0.001$)

Table 31: Mean sensory scores for cooked seed taste with farmers and consumers during crop and Ratoon Crops at Kambi ya Mawe and Kiboko-2012/13

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.4cd	3.4ab	3.6a	4.8d	5.1a	4.9ab
ICEAP 00540	4.6bcd	4.1bc	4.6a	3.9abcd	5.2a	3.7a
ICEAP 00554	5.6d	5.6d	4.3a	4.4abcd	4a	4.9ab
ICEAP 00557	4.3bcd	4.1bc	4.6a	4.7cd	4.4a	5.4ab
ICEAP 00850	4.9cd	3.2ab	3.9a	4.6bcd	4.1a	5.1ab
ICEAP 00902	4.9cd	5.1cd	4.3a	4.8d	4.6a	4.9ab
ICEAP 00911	3.4ab	4.1bc	4.7a	4.2abcd	5.1a	4.2ab
ICP 7035 B	2.9a	3.6ab	4.5a	3.3abc	4.1a	5.2ab
KAT 60/8	5.2cd	4.2bc	4.1a	5d	4.9a	4a
MTHAWAJUNI	4.2abc	2.7a	3.3a	4.1abcd	4.6a	4.5ab
MZ 2/9	4.7bcd	2.6a	3.7a	3.2ab	4.3a	5.7b
KIONZA	N/A	N/A	3.9a	3.1a	4.7a	4.9ab
CV% (Genotype)	27.3	31.8	34.5	32.7	27.8	27.7
LSD$_{(0.05)}$ Genotype (G)	0.8***	0.8***	0.78*	0.84***	0.95^{NS}	0.99**
LSD$_{(0.05)}$ Season (S)	0.28***	0.27NS				
LSD$_{(0.05)}$ G x S	0.63***	0.61**				
CV% (G x S)	32.5	33.7				
LSD$_{(0.05)}$ Location (L)	0.25***		0.25^{NS}		0.29^{NS}	
LSD$_{(0.05)}$ G x L	0.83***		0.86***		0.99***	
CV% (G x S)	30.0		33.7		28.6	

*, **, *** significant at, $P\leq0.05$, $P\leq0.01$, and $P\leq0.001$ respectively

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

Location had a significant influence on genotypes only during Main Crop ($P<0.05$). Interaction between genotype and location (G x L) was significant ($P<0.001$). Acceptance evaluation of vegetable pigeonpea genotypes for cooked seed taste recorded a mean of 4.6 at KYM, while at Kiboko, a mean of 3.9, was recorded. ICEAP 00554 (5.6), ICEAP 00068 (5.4) and KAT 60/8 (5.2) were the most preferred at KYM while at Kiboko, ICEAP 00554 (5.6), ICEAP 00902 (5.1) and KAT 60/8 (4.2) were the most preferred. Across the locations, ICEAP 00554 (5.6), ICEAP 00902 (5.0) and KAT 60/8 (4.7) were the most preferred genotypes. During ratoon Crop, panelists scored a mean of 4.1 at KYM, while at Kiboko, a mean of 4.1 was recorded. At KYM, ICEAP 00911 (4.7), ICEAP 00540 (4.6) and ICEAP 00557 (4.6) were the most preferred genotypes, while at Kiboko, KAT 60/8 (5.0), ICEAP 00068 (4.8) and ICEAP 00902 (4.8) were the most preferred. Sensory Acceptance evaluation with panelists indicated a mean of 4.6, at KYM, while at Kiboko recorded a mean of 4.8. ICEAP 00911 (5.1), ICEAP 00068 (5.1) and ICEAP 00540 (5.2) were the most preferred at KYM. At Kiboko, ICP 7035B (5.2), ICEAP 00557 (5.4) and MZ 2/9 (5.7) were the most preferred. ICEAP 00068 (5.0) and ICEAP 00557 (4.9) were the most preferred across the locations.

Taste is an important parameter when evaluating sensory attribute of food (Muhimbila *et al.*, 2011), for acceptance. A product might be appealing but without good taste, such product is likely to be unacceptable. Farmers have shown preference for genotypes with green seed color. These genotypes include ICEAP 00554, ICEAP 00068, KAT 60/8 and ICEAP 00902, compared to brown/bronze speckled seed colored genotypes like MZ 2/9, Mthawajuni and ICP 7035B. This shows that color of the seed influenced the Aroma of the pigeonpea genotype seeds. The brown/speckled bronze seed colored genotypes could be having a bitter taste that is why they were scored poorly. Bressani and Elias (1980) and Guzman-Madondo *et al.*, (1996) reported that dark colored legume seeds may have a higher content of phenolic compounds, such as condensed tannins, which may contribute a bitter taste after cooking beans. They concluded that most consumers prefer lighter bean seed compared to dark colored seed. Mkanda *et al.*, (2007) observed that dark stripped beans were reported to be bitterer than the lighter colored ones in a sensory study of common beans and concluded that bitter taste contributes to consumers' dislike of bean genotypes. Same results have been reported by Akinjayeju and Enude (2002) and Akinjayeju and Bisiriyu (2004) on beans. Enwere (1998) associated the non-preference of colored beans to characteristic beany flavor in most legumes which is prevalent mostly in the seed coat and considered offensive to most consumers

4.9.4 PIGEONPEA SEED TEXTURE

Sensory evaluation for acceptance was carried out to assess the acceptability of vegetable pigeonpea genotypes based on texture (Mouth and hand feel) by farmers and panelists after cooking. Genotypes were significantly different ($P<0.001$) during main crop and ratoon crops, but were not significant during the evaluation with panelists ($P<0.05$), on seed texture after cooking (Table 32). Main crop and ratoon crops were significantly different at KYM ($P<0.001$) but not significant at Kiboko ($P<0.05$). There was a significant interaction between season and genotypes (G x S) at KYM ($P<0.001$) and Kiboko ($P<0.01$), as presented in table 27. Locations had a significant influence on genotype seed texture during crop ($P<0.001$), but non-significant during evaluation during Ratoon Crop with farmers and panelists ($P<0.05$). Interaction between location and genotypes (G x L) were significant ($P<0.001$) during crop, ratoon and evaluation with consumers during ratoon crop. The mean preference during Main Crop on texture was 4.3 at Kambi ya Mawe, while at Kiboko, they recorded a mean of 3.9. At KYM, ICEAP 00554 (5.3), ICEAP 00068 (5.1) and Mthawajuni (4.7) were the most preferred genotypes while at Kiboko, ICEAP 00554 (5.3), ICEAP 00902 (4.7) and ICEAP 00911 (4.3) were the most preferred. During the ratoon crop, the mean texture was 4.8 at KYM. KIONZA (5.8), Mthawajuni (5.6), and KAT 60/8 (5.5) were the most preferred at KYM. At Kiboko, ICEAP 00068 (5.1), ICEAP 00540 (4.9) and KAT 60/8 (4.8) were the most preferred. ICEAP 00850 (5.0), Mthawajuni (5.0) and KAT 60/8 (5.1) were the most preferred genotypes. 4 (5.3), ICEAP 00902 (4.7) and ICEAP 00068 (4.4) were the most preferred at both locations.

Panelists recorded a mean scores of 5.0, at KYM, while at Kiboko, it recorded a mean of 5.2. ICEAP 00540 (4.5), ICEAP 00068 (5.0), ICEAP 00911 (4.6) were the most preferred at KYM, while at Kiboko, ICEAP 00557 (6.0), Mthawajuni (5.9) and MZ 2/9 (5.6) were the most preferred genotypes. Seed size may having a significant effect on the texture of the vegetable pigeonpea genotypes.

Table 32: Mean sensory scores for seed Texture with farmers and consumers during crop and Ratoon Crops at Kambi ya Mawe and Kiboko-2012/13

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.1c	3.7abcd	4ab	5.1c	6.1cd	5ab
ICEAP 00540	4.3bc	3.9abcd	4.8abcd	4.9bc	6.1cd	4.6ab
ICEAP 00554	5.3c	5.3e	4.3abc	4.4abc	4.2ab	4.8ab
ICEAP 00557	3.6ab	3.6abcd	4.8abcd	4.5abc	4.1ab	6b
ICEAP 00850	4.4bc	4.1abcd	5.2bcd	4.8bc	3.5a	5.2ab
ICEAP 00902	4.7bc	4.7de	4.3abc	4.6abc	4.4ab	5.2ab
ICEAP 00911	3.8ab	4.3cde	4.8abcd	4.7abc	6.4d	4.9ab
ICP 7035 B	2.8a	3.3abc	4.6abcd	3.3a	4.4ab	5.4ab
KAT 60/8	4.4bc	4.1bcde	5.5cd	4.8bc	6cd	4.2a
MTHAWAJUNI	4.7bc	3.1ab	5.6cd	4.4abc	4.9abc	5.9b
MZ 2/9	4.6bc	2.8a	3.6a	3.5ab	5bcd	5.6ab
KIONZA	N/A	N/A	5.8d	3.6abc	5.3bcd	5.3ab
CV% (Genotype)	27	29.5	28.8	32.8	23.1	22.9
LSD$_{(0.05)}$ Genotype (G)	0.8***	0.8***	0.85***	0.89***	0.87***	0.88***
LSD$_{(0.05)}$ Season (S)	0.26*	0.27*				
LSD$_{(0.05)}$ G x S	0.59***	0.62**				
CV% (G x S)	28.5	33.1				
LSD$_{(0.05)}$ Location (L)	0.24***		0.25**		0.25^{NS}	
LSD$_{(0.05)}$ G x L	0.78***		0.87***		0.87***	
CV% (G x S)	28.9		30.7		22.8	

*, **, *** significant at, P≤0.05, P≤0.01, and P≤0.001 respectively

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

Olapade, *et al.*, (2002) observed that seed size is a quality that has been associated with the cooking time of legumes. He observed that conduction is anticipated to be the primary mode of heat transfer within cowpea seeds and therefore, smaller seeds receive heat faster in the interior during cooking. The colored genotypes recorded a mean seed weight of 30grams/100, compared to 23grams/100 seeds for the green seeded genotypes. The low texture quality in colored genotypes could have been associated with chemical composition in the seed coat, which interferes with the cook ability, in which cook ability refers to the condition by which seeds achieves a degree of tenderness during cooking, which is acceptable to consumers (Sharma *et al.*, 2011).

The colored genotypes recorded a mean seed weight of 30grams/100, compared to 23grams/100 seeds for the green seeded genotypes. Brown/bronze/speckled seeded pigeonpeas were observed by Oboh (2007) to have the highest levels of phenolic (1.2 mg/g tannic acid equivalent). Phenolic compounds in white/green pigeonpeas were significantly lower at 0.4 mg/g tannic acid equivalents. Singh, (1993) noted that 80–90% of polyphenols were present in the seed coat of pigeonpeas. The white/green seeded cultivars contain relatively less amounts of polyphenols (Saxena *et al.*, 2010b). Such cultivars are preferred in many countries where de-hulling facilities are not available and whole seeds are consumed. In comparison to the white/green seeded cultivars the red seeded types contain three times greater quantity of polyphenols and enzyme inhibition activity was also greater in the colored seeds of pigeonpea (Singh, 1984).

4.9.5 OVERALL PIGEONPEA SEED ACCEPTABILITY

Vegetable pigeonpea seeds were evaluated for the overall acceptance by both famers and panelists during the main crop and ratoon crop, as presented in table 33 below. The genotypes differed on overall preference during evaluation by farmers at crop and ratoon crops and panelists during Ratoon Crop. There was no influence of season on overall acceptability at both KYM and Kiboko ($P<0.05$), while Interaction between main crop, ratoon and genotypes (G x S) was significant ($P<0.001$) at both locations. Location had a significant influence on overall acceptability, and was significant ($P<0.001$) during both main and ratoon crops evaluation by farmers and ($P<0.05$) with panelists during the ratoon crop. Interaction between location and genotype (G x L) was significant ($P<0.001$) during crop and Ratoon Crop with farmers and ($P<0.05$) with consumers during Ratoon Crop. During the Main Crop, the mean of 4.9 was recorded at KYM, while at Kiboko, a mean of 3.8 was achieved.

Table 33: Mean sensory scores for overall acceptance with farmers and consumers during crop and Ratoon Crops at Kambi ya Mawe and Kiboko-2013

	Main Crop (Farmers)		**Ratoon Crop (Farmers)**		**Panelists (UON)**	
Genotype	**KYM**	**KIB**	**KYM**	**KIB**	**KYM**	**KIB**
ICEAP 00068	5.4cd	3.5b	5abcd	5.1c	6.1ef	5.9bc
ICEAP 00540	5.3cd	4.4bcde	5.1bcd	5.5c	5.9def	5.1abc
ICEAP 00554	5.9d	5.9f	5.6cd	4.3abc	5bcd	5.7bc
ICEAP 00557	4.8bc	4.8de	5.5bcd	5.2c	4.2ab	6.1c
ICEAP 00850	4.8bc	4.2bcde	5.3bcd	5.4c	3.8a	5.5abc
ICEAP 00902	5.2cd	5.2ef	5.1abcd	5c	5bcd	5.6bc
ICEAP 00911	4ab	5.1ef	5abcd	4.9bc	6.1f	5abc
ICP 7035 B	3.1a	3.8bcd	5.3bcd	3.4ab	4.1ab	4.8ab
KAT 60/8	5.1bcd	4.6cde	6d	5.2c	5.4cdef	4.7ab
MTHAWAJUNI	4.9bcd	3.6bc	4.6abc	4.3abc	4.1ab	5.1abc
MZ 2/9	5.4cd	2.3a	3.8a	3.2a	5.1bcde	4.4a
KIONZA	N/A	N/A	4.2ab	3.1a	4.6abc	5.1abc
CV% (Genotype)	20.3	22.8	24.1	30.9	16.8	17.7
$\text{LSD}_{(0.05)}$ Genotype (G)	0.7***	0.6***	**0.75*** **	0.87***	0.62***	0.69***
$\text{LSD}_{(0.05)}$ Season (S)	0.23^{NS}	0.26^{NS}				
$\text{LSD}_{(0.05)}$ G x S	0.53***	0.58***				
CV% (G x S)	23.7	29.2				
$\text{LSD}_{(0.05)}$ Location (L)	0.19***		0.24***		0.19**	
$\text{LSD}_{(0.05)}$ G x L	0.66***		0.84**		0.69***	
CV% (G x S)	21.9		28.2		18.2	

*, **, *** significant at, $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ respectively

Means with the same letter are not significantly different at the 0.05 probability level by Turkey's test

ICEAP 00554 (5.9), ICEAP 00068 (5.4) and MZ 2/9 (5.4) were the most accepted genotypes at KYM, at Kiboko, ICEAP 00554 (5.9), ICEAP 00902 (5.2) and ICEAP 00911 (5.1) were the most accepted. During the ratoon crop, the mean overall acceptance was 5.0 at KYM. KAT 60/8 (6.0), ICEAP 00554 (5.6) and ICEAP 00557 (5.5) were the most accepted genotypes. At Kiboko, ICEAP 00540 (5.5), ICEAP 00850 (5.4) and KAT 60/8 (5.2) were the most accepted. Acceptance evaluation with panelists during ratoon Main Crop recorded a mean overall acceptance range of 5.0, at KYM, while at Kiboko, a mean of 5.3. ICEAP 00540 (5.9), ICEAP 00068 (6.1), ICEAP 00911 (6.1) were the most accepted at KYM. At Kiboko, ICEAP 00554 (5.7), ICEAP 00068 (5.9) and ICEAP 00557 (6.1) were the most accepted genotypes. The significant difference in color, taste, appearance, and texture, could have led to significant difference in overall acceptability among the genotypes. It's therefore observed that sensory quality of vegetable pigeonpea is a combination of different senses of perceptions, coming into play in choosing the genotype to be consumed.

Appearance, color, taste, and textures decides the overall acceptance of vegetable pigeonpea genotypes. The overall preference confirms the selection behavior among the farmers and panelists. During main Crop, ICEAP 00902 and KAT 60/8 were accepted at both locations. Based on Overall acceptability, MZ 2/9 and ICP 7035 were consistently not accepted at Kambi ya Mawe and Kiboko respectively. The panelists scored above 4.0 for all the genotypes at Kiboko, but rated ICEAP 00850 (Appearance, aroma and texture) below 4.0 at Kambi ya Mawe.

CHAPTER FIVE: GENERAL DISCUSSIONS, CONCLUSIONS, AND RECOMMENDATION

5.1 EVALUATION FOR VEGETABLE YIELD POTENTIAL

Performance of vegetable pigeonpeas under rain-fed and supplementary irrigation was carried out at Kambi ya Mawe and Kiboko research stations, located in Makueni County, between October, 2012 and August 2013. Twelve medium duration pigeonpea genotypes (ICP 7035B, ICEAP 00068, MTHAWAJUNI, MZ 2/9, KAT 60/8, ICEAP 00540, ICEAP 00557, ICEAP 00911, ICEAP 00902, ICEAP 00554, ICEAP 00850 and KIONZA), currently being grown by smallholder farmers in the region, for dry grain, were tested, in randomized block design (RCBD), replicated three time. Agronomic and cultural practices were done during main crop and Ratoon Crops. Data was collected based on 14 parameters for yield evaluation. Weather data for both locations, during crop and Ratoon Crops were also collected and analyzed.

The rainfall at both locations were favorable for pigeonpea growth, with Kambi ya Mawe recording 592 mm, while Kiboko realized 215 mm. Compared to the previous year, 2011/12, rains at Kiboko were enhanced by 17 percent, while at Kambi ya Mawe, it was enhanced by 7 percent. The low rainfall realized at Kiboko of 215 mm during the short rains, was supplemented with irrigation. With about 300 mm of irrigation water being applied, at Kiboko, genotype productivity during the Main Crop was almost the same, with that at Kambi ya Mawe recording 1,988 Kg/ha, while Kiboko recording 2,269 Kg/ha, a difference of 14 percent. During the Ratoon Crop, the rains were lower at Kambi ya Mawe, recording 123 mm, while Kiboko recorded 317 mm. With supplementary irrigation at Kiboko and reduced rainfall at Kambi ya Mawe, there was a big difference of 101 percent in yield, with Kambi ya Mawe recording 1,962 Kg/ha compared to that at Kiboko of 5,888 Kg/ha. The non-significance yield difference among the genotypes within the locations indicates a narrow genetic diversity, which was expected since these genotypes were previously evaluated and selected for dry grain yield productivity.

These results indicate that under sufficient soil moisture, in rain-fed conditions, genotypes can produce comparable yields with irrigated conditions. The potential for supplementary irrigation for improve yields of vegetable pigeonpeas was observed at Kiboko. Improved soil moisture had a positive influence on all the characters, except on shelling percent, which was reduced by 7 percent. Plant height was the most influenced, recording a 105 percent increase, followed by grain weight by 47 percent, pods per plant by 31 percent, duration to flower and maturity by 30 and 29 percent respectively. Pod length, pod width and 100 seed mass were enhanced by 6, 8, and 8 percent enhancement respectively. The study observed a significant and positive association between number of pods per plant and grain yield, which shows that pods per plant is a major yield contributing characters in vegetable pigeonpea, and can be used to select genotypes with high yield potential. An increase in number of pods under rain-fed conditions lead to increase in seed size, and therefore high shelling percent. Higher seed size and shelling percentage translates to high yields, especially during Ratoon Crop. Under supplementary irrigation, increase in pods per plant reduced seed mass (g/100 seed), and therefore reduced shelling percentage, as observed at Kiboko.

Temperature was observed to have significant effect on growth and development of vegetable pigeon pea genotypes, with greatest effect being observed at flowering phase. While increase in temperature during vegetative phase under rain-fed condition positively and significantly accelerates growth and development, under supplementary irrigation, it had a positive effect though not significant. Increase in temperature during vegetative phase accelerated plant maturity, plant height, pod length and width, seed per pod and improves seed mass under rain-fed condition. Increase in mean temperature, during the flowering phase leads to reduction in duration to flowering and maturity, yields, seed mass and plant height. Supplementary irrigation could be creating a micro-climate, and increased moisture content, reducing significant effect of increased temperature, at Kiboko.

This study has observed that genotypes that take longer to flower and mature, reported lower yields of vegetable pigeonpeas. Late maturing genotypes with a mean of 122 DTF, gave lower yields of 3,839 Kg/ha, compared to early maturing genotypes with a mean of 100 DTF, recording a mean yield of 5,754 Kg/ha. This supports the negative and significant correlation between duration to flower and maturity and yields. As duration increase, the genotypes are exposed to limited moisture under rain-fed conditions and low temperature under supplementary irrigation, leading to reduced yields. Selection of genotypes that are early maturing and adopted to the local conditions will be important. This study has been able to identify six genotypes that have high yielding potential for vegetable pigeonpea production under rain fed and supplementary irrigation in Makueni County. The following were genotypes were therefore noted to have stable yields under both rain fed and supplementary irrigation: MZ 2/9, ICEAP 00911, ICEAP 00068, ICEAP 00902, Mthawajuni, ICEAP 00554, and KAT 60/8. While ICEAP 00557 and ICP 7035B performed better under irrigation, ICEAP 00540 performed better only under rain fed condition.

5.2 SENSORY EVALUATION FOR PREFERENCE AND ACCEPTABILITY

Vegetable pigeonpea seed preference and acceptability study was undertaken between February and July, 2013, with the objective of determining the acceptability and preference of vegetable medium duration Pigeonpea genotypes among the farmers and panelists, using sensory characteristics in the Eastern region of Kenya. Six sensory parameters: Seed color, Seed appearance, Seed taste, Seed aroma, Seed texture and overall acceptance were scored based on the Hedonic scale of 1-7 (1-dislike very much and 7-Like very much) at both location for both seasons. Based on overall acceptance, only ICP 7035B scored below 4.0 on all the parameters at Kambi ya Mawe during Main Crop. At Kiboko, ICP 7035B and ICEAP 00068 score below 4.0 based on overall acceptance. ICEAP 00068 scored above 4.0 on seed color, while all other parameters were below 4.0, at Kiboko. During Ratoon Crop, MZ 2/9 score below 4.0 in all the parameters at Kambi ya Mawe, while ICP 7035, MZ 2/9, and KIONZA score below 4.0 in all the measured parameters at Kiboko. Sensory evaluation with panelist scored above 4.0 on overall appearance on all the genotypes at Kambi ya Mawe, except ICEAP 00850 (aroma, texture and appearance), ICEAP 00911 (Seed color) and Mthawajuni (Seed appearance and seed color).

This study has shown that farmers and panelists, when selecting genotype based on appearance, seed color is the main determinant, rather than the seed size. Genotypes such as ICEAP 00554, ICEAP 00068 and KAT 60/8, though having low seed size, were the most preferred, compared to the heavy seeded, brown/bronze speckled genotypes such as MZ 2/9, Mthawajuni and ICP 7035B. Surface characteristics of food products contribute to the appearance. Brown, speckled or bronze colored genotypes such as MZ 2/9, Mthawajuni, and ICP 7035B were scored poorly by both farmers and panelists. Farmers were more attracted to what they are used to see in pigeonpea, while consumers related to the color of green peas. Khan and Arvanitoyannis (2003), observed that high overall impression of the bean was closely related to color. The color of vegetable pigeonpea influences their acceptability, and therefore, breeding of improved genotypes should be towards green/light/pale seed coat color.

Farmers have shown preference for genotypes with green seed color, for taste and odor/smell. These genotypes include ICEAP 00554, ICEAP 00068, KAT 60/8 and ICEAP 00902, compared to brown/bronze speckled seed colored genotypes like MZ 2/9, Mthawajuni and ICP 7035B. The brown/speckled bronze seed colored genotypes could be having a bitter taste that is why they were scored poorly. Bressani and Elias (1980) and Guzman-Madondo *et al.*, (1996) reported that dark colored legume seeds like brown/bronze/speckled colored legume seed, may have a higher content of phenolic compounds, such as condensed tannins, which may contribute a bitter taste after cooking beans. Enwere (1998) associated the non-preference of colored beans to characteristic beany flavor in most legumes which is prevalent mostly in the seed coat and considered offensive to most consumers. Seed size may having a significant effect on the tenderness of the vegetable pigeonpea genotypes. The colored genotypes recorded a mean seed weight of 30grams/100, compared to 23grams/100 seeds for the green seeded genotypes. Olapade, *et al.*, (2002) observed that seed size is a quality that has been associated with the cooking time of legumes. The low tenderness quality in colored genotypes could have been associated with chemical composition in the seed coat, which interferes with the cook ability, in which cook ability refers to the condition by which seeds achieves a degree of tenderness during cooking, which is acceptable to consumers (Sharma *et al.*, 2011).

5.3 RECOMMENDATIONS

This study has been able to identify genotypes with high productivity potential, preferred, and acceptable, under rain fed and supplementary irrigation, in the Eastern region of Kenya. These genotypes include: ICEAP 00068, ICEAP 00540, ICEAP 00554, ICEAP 00902, KAT 60/8 and MZ 2/9 for rain-fed conditions and ICEAP 00902, ICEAP 00068, ICEAP 00557, ICEAP 00554, KAT 60.8 and MTHAWAJUNI under supplementary irrigation. While the yields under rain-fed condition for the selected genotype ranged from 3,384 Kg/ha (KAT 60/8) to 5,959 Kg/ha (MZ 2/9), under supplementary irrigation it ranged from 5,861 Kg/ha (ICEAP 00068) to 7,357 Kg/ha (Mthawajuni). All the genotypes scored above 4.0 in all the parameters considered during sensory evaluation. Other genotypes that produced high yields but were not preferred by both farmers and consumers were: Mthawajuni (3,954 Kg/ha) and ICEAP 00911 (5,299 Kg/ha) at Kambi ya Mawe, under rain-fed, and ICP 7035B (5,736 Kg/ha) and MZ 2/9 (7,563 Kg/ha) under supplementary irrigation, at Kiboko. The study proposes the above genotypes to be promoted in the respective conditions as vegetable pigeonpeas. Genotypes KAT 60/8, ICEAP 00068, ICEAP 00554, and ICEAP 00902 are suitable for production under both rain-fed and supplementary irrigation due to preference by farmers and consumers and high productivity. Based on these findings it is therefore recommended that for productivity:

- As water resource become expensive and scarce, for both on station and on-farm irrigation, there is a need to identify the stage in vegetable pigeonpea growth, in which irrigation will have the greatest impact on yield, instead of irrigating throughout the growth phase, leading to high expenditure in terms of labor and rates on water use.
- Further study on the relationship between grain yield and yield variables on vegetable pigeonpeas, based on path coefficient analysis should be done, to determine the direct and indirect effect of these variables to yield. Correlation coefficient measures the mutual association between a pair of variables independent of other variables to be considered, without providing the nature of cause and effect relationship of each character.
- Stability analysis on yield under different vegetable pigeonpea growing locations in Kenya need to be undertaken.

Based on the findings of this study, it therefore recommended that for preference and acceptability:

- Further research should be done to evaluate the mineral and proximate composition of the genotypes under supplementary irrigation and rain fed conditions.
- There is need to determine the stage during pod growth, when mineral and proximate composition is at its maximum.
- It is apparent that consumers prefer green seeded pigeonpea genotypes than brown/bronze colored genotypes. Based on productivity, brown colored genotypes recorded the highest yields. It is therefore recommended that breeding through backcrossing to change the seed color of these brown/bronze/speckled colored genotypes be done, to improve their preference and acceptability by both farmers and consumers.
- Sensory evaluation with traders' on preference and acceptability of the vegetable genotypes will be important.

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APPENDIX 1.0: SENSORY/ORGANOLEPTIC EVALUATION OF PIGEONPEAS

Name (optional) ------------------------------------**Site**---------------------**Date** ---------------------

You are provided with **11** samples of cooked pigeon pea samples to evaluate for sensory acceptability. Use the chart (key) below to indicate your degree of liking of each attribute for each pigeon pea variety given in the Table.

CHART/KEY FOR SCORING

7 – Like very much
6 – Like moderately
5 – Like slightly
4 – Neither like nor dislike
3 – Dislike slightly
2 – Dislike moderately
1 – Dislike very much

Without tasting, score for the color, and appearance

Then taste each pigeon pea sample and score for taste, odor/smell, tenderness/softness, and overall acceptance

TABLE OF SAMPLES AND ATTRIBUTES

Sample	Color	Appearance	Taste	Odor/smell	Tenderness/ softness	Overall acceptance
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Any other comments

APPENDICES 2.0: ANOVA TABLES FOR YIELD VARIABLES: MAIN CROP

2.1 LOCATION: KIBOKO

Grain Yield (Kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate	2	1968125.	984062.	2.06	
Treatment	11	8302213.	754747.	1.58	0.173
Residual	22	10501439.	477338.		
Total	35	20771777.			

Days to Flower

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	224.39	112.19	6.11	
Treatment	11	30718.97	2792.63	151.97	<.001
Residual	22	404.28	18.38		
Total	35	31347.64			

Days to 75% Mature

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate	2	26.39	13.19	0.53	
Treatment	11	35443.22	3222.11	129.45	<.001
Residual	22	547.61	24.89		
Total	35	36017.22			

Seed Mass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	5.143	2.572	0.59	
Treatment	11	672.488	61.135	14.03	<.001
Residual	22	95.883	4.358		
Total	35	773.514			

Primary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	3.500	1.750	0.37	
Treatment	11	280.750	25.523	5.37	<.001
Residual	22	104.500	4.750		
Total	35	388.750			

Plant Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	574.9	287.4	1.79	
Treatment	11	19751.9	1795.6	11.18	<.001
Residual	22	3534.4	160.7		
Total	35	23861.2			

Pod Length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	0.8957	0.4478	1.41	
Treatment	11	5.5385	0.5035	1.59	0.170
Residual	22	6.9636	0.3165		
Total	35	13.3978			

Pods per Plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	12872.	6436.	2.25	
Treatments	11	62375.	5670.	1.98	0.083
Residual	22	62925.	2860.		
Total	35	138171.			

Plant stand

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	77.167	38.583	5.83	
Treatments	11	267.333	24.303	3.67	0.005
Residual	22	145.500	6.614		
Total	35	490.000			

Pod width

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	0.041317	0.020658	2.58	
Treatment	11	0.333742	0.030340	3.79	0.004
Residual	22	0.176217	0.008010		
Total	35	0.551275			

Secondary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	475.72	237.86	7.22	

Treatments	11	2521.64	229.24	6.96	<.001
Residual	22	724.94	32.95		
Total	35	3722.31			

SHELL Percent

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	7.07	3.54	0.07	
Genotype	11	463.73	42.16	0.88	0.571
Residual	22	1052.84	47.86		
Total	35	1523.64			

Seed per pod

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	0.3889	0.1944	1.00	
Genotype	11	8.9722	0.8157	4.19	0.002
Residual	22	4.2778	0.1944		
Total	35	13.6389			

2.2 KAMBI YA MAWE RESEARCH STATION

Grain Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	1952303.	976152.	2.73	
Treatment	11	11185842.	1016895.	2.85	0.018
Residual	22	7860140.	357279.		
Total	35	20998285.			

Days to flower

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	89.56	44.78	2.12	
Treatment	11	25753.22	2341.20	111.06	<.001
Residual	22	463.78	21.08		
Total	35	26306.56			

Days to 75 percent Maturity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	102.17	51.08	1.52	
Replicate	11	32842.08	2985.64	88.94	<.001
Residual	22	738.50	33.57		

Total	35	33682.75			

Seed Mass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	1.877	0.938	0.41	
Treatment	11	612.182	55.653	24.57	<.001
Residual	22	49.827	2.265		
Total	35	663.886			

Primary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	1.860	0.930	0.12	
Treatments	11	120.377	10.943	1.42	0.233
Residual	22	169.793	7.718		
Total	35	292.030			

Plant height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	216.0	108.0	0.85	
Treatment	11	21278.1	1934.4	15.16	<.001
Residual	22	2806.4	127.6		
Total	35	24300.4			

Pod length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	0.1077	0.0539	0.20	
Treatments	11	17.7939	1.6176	5.88	<.001
Residual	22	6.0562	0.2753		
Total	35	23.9578			

Pods per plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	581.	290.	0.22	
Treatment	11	7815.	710.	0.54	0.858
Residual	22	29141.	1325.		
Total	35	37537.			

Pod width

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

REP stratum	2	0.02987	0.01494	1.45	
Treatment	11	0.27063	0.02460	2.39	0.040
Residual	22	0.22666	0.01030		
Total	35	0.52716			

Secondary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	35.76	17.88	0.21	
Treatment	11	2156.38	196.03	2.27	0.049
Residual	22	1896.58	86.21		
Total	35	4088.73			

Shelling Percent

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	79.10	39.55	1.18	
Treatment	11	699.34	63.58	1.89	0.097
Residual	22	738.42	33.56		
Total	35	1516.86			

Seed per pod

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	0.66667	0.33333	3.54	
Treatment	11	11.03704	1.00337	10.64	<.001
Residual	22	2.07407	0.09428		
Total	35	13.77778			

APPENDICES 3.0: ANOVA TABLES FOR YIELD VARIABLES: RATOON CROP

3.1 LOCATION: KIBOKO

Grain Yield (Kg/ha)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	4188990.	2094495.	3.61	
Treatment	10	7813037.	781304.	1.35	0.273
Residual	20	11592467.	579623.		
Total	32	23240398.			

Days to Flower

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		108.64	54.32	2.93	
Treatment	10	(1)	856.06	85.61	4.61	0.002
Residual	20	(2)	371.21	18.56		
Total	32	(3)	1326.73			

Days to 75% Maturity

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		40.03	20.01	0.78	
Treatment	10	(1)	1187.21	118.72	4.62	0.002
Residual	20	(2)	513.88	25.69		
Total	32	(3)	1737.88			

Seed Weight (gms/100 seeds)

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		52.224	26.112	5.63	
Treatment	10	(1)	487.060	48.706	10.51	<.001
Residual	20	(2)	92.697	4.635		
Total	32	(3)	627.567			

Primary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	3.384	1.692	0.32	
Treatment	10	97.069	9.707	1.86	0.115
Residual	20	104.648	5.232		
Total	32	204.802			

Plant Height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	3662.7	1831.4	2.05	
Treatment	10	12864.9	1286.5	1.44	0.234
Residual	20	17888.2	894.4		
Total	32	34106.2			

Pod Length

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		3.3227	1.6613	5.67	
Treatment	10	(1)	8.3034	0.8303	2.83	0.023
Residual	20	(2)	5.8595	0.2930		
Total	32	(3)	17.2048			

Pods per plant

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		3211.0	1605.5	2.02	
Treatment	10	(1)	8987.5	898.7	1.13	0.389
Residual	20	(2)	15907.8	795.4		
Total	32	(3)	27834.9			

Pod width

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		0.038874	0.019437	3.44	
Treatment	10	(1)	0.185091	0.018509	3.28	0.011
Residual	20	(2)	0.112946	0.005647		
Total	32	(3)	0.333624			

Secondary Branches

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	2	455.97	227.98	7.02	
Treatment	10	1273.48	127.35	3.92	0.004
Residual	20	649.14	32.46		
Total	32	2340.04			

Shelling percent

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		6.45	3.22	0.10	

Treatment	10	(1)	296.73	29.67	0.95	0.515
Residual	20	(2)	627.09	31.35		
Total	32	(3)	929.79			

Seed per pod

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		1.3902	0.6951	3.42	
Treatment	10	(1)	5.5758	0.5576	2.75	0.026
Residual	20	(2)	4.0606	0.2030		
Total	32	(3)	10.9091			

3.2 LOCATION KAMBI YA MAWE

Grain Yield (Kg/ha)

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		2173895.	1086947.	2.04	
Genotypes	10	(1)	12804058.	1280406.	2.41	0.045
Residual	20	(2)	10632523.	531626.		
Total	32	(3)	25426716.			

Days to 50% Flowering

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		16.02	8.01	0.58	
Genotypes	10	(1)	709.21	70.92	5.09	<.001
Residual	20	(2)	278.61	13.93		
Total	32	(3)	1002.55			

Days to 75% mature

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		166.4	83.2	0.63	
Genotypes	10	(1)	1325.2	132.5	1.00	0.476
Residual	20	(2)	2650.4	132.5		
Total	32	(3)	4128.5			

Seed weight (gms/100seed)

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		2.979	1.489	0.41	
Genotypes	10	(1)	816.957	81.696	22.41	<.001
Residual	20	(2)	72.899	3.645		

Total	32	(3)	892.572			

Primary Branches

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		1.044	0.522	0.09	
Genotypes	10	(1)	91.261	9.126	1.59	0.182
Residual	20	(2)	115.140	5.757		
Total	32	(3)	207.367			

Plant height

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		621.4	310.7	0.79	
REP.*Units* stratum						
TRT	10	(1)	3773.6	377.4	0.96	0.507
Residual	20	(2)	7884.9	394.2		
Total	32	(3)	12229.6			

Pod Length

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		5.870	2.935	1.36	
Genotypes	10	(1)	28.691	2.869	1.33	0.281
Residual	20	(2)	43.160	2.158		
Total	32	(3)	77.246			

Pods per plant

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		7263.	3631.	2.78	
Genotypes	10	(1)	29992.	2999.	2.29	0.055
Residual	20	(2)	26167.	1308.		
Total	32	(3)	62808.			

Plant stand

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		18.00	9.00	0.74	
Genotypes	10	(1)	465.21	46.52	3.80	0.005
Residual	20	(2)	244.79	12.24		
Total	32	(3)	726.55			

Pod Width

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		0.04228	0.02114	0.47	
Replicate	10	(1)	0.72359	0.07236	1.61	0.175
Residual	20	(2)	0.89954	0.04498		
Total	32	(3)	1.66199			

Secondary Branches

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		94.46	47.23	0.51	
Genotypess	10	(1)	2266.32	226.63	2.46	0.042
Residual	20	(2)	1845.82	92.29		
Total	32	(3)	4198.96			

Shelling Percent

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		140.77	70.38	3.08	
Genotypes	10	(1)	499.09	49.91	2.18	0.066
Residual	20	(2)	456.95	22.85		
Total	32	(3)	1084.90			

Seed per Pod

Source of variation	d.f.	(m.v.)	s.s.	m.s.	v.r.	F pr.
REP stratum	2		5.362	2.681	1.84	
Genotypes	10	(1)	8.727	0.873	0.60	0.796
Residual	20	(2)	29.091	1.455		
Total	32	(3)	42.727			

APPENDICES 4.0: ANOVA TABLES FOR SENSORY EVALUATION WITH FARMERS DURING MAIN CROP

4.1 LOCATION: KIBOKO

Appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	62.737	7.842	4.68	
Genotype	10	144.384	14.438	8.62	<.001
Residual	179	299.707	1.674		
Total	197	506.828			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	34.253	4.282	2.10	
Genotype	10	189.343	18.934	9.29	<.001
Residual	179	364.747	2.038		
Total	197	588.343			

Odor Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	39.859	4.982	4.40	
Genotype	10	148.980	14.898	13.17	<.001
Residual	179	202.475	1.131		
Total	197	391.313			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	32.7980	4.0997	4.24	
Genotype	10	174.3737	17.4374	18.04	<.001
Residual	179	173.0354	0.9667		
Total	197	380.2071			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	26.434	3.304	2.20	
Genotype	10	153.919	15.392	10.27	<.001
Residual	179	268.399	1.499		

Total	197	448.753			

Tenderness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	36.071	4.509	3.40	
Genotype	10	94.424	9.442	7.12	<.001
Residual	179	237.485	1.327		
Total	197	367.980			

3.2 LOCATION: KAMBI YA MAWE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Testers	8	150.182	18.773	14.87	
Genotypes	10	169.152	16.915	13.40	<.001
Residual	179	225.985	1.262		
Total	197	545.318			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Testers	8	157.465	19.683	16.33	
Genotypes	10	217.232	21.723	18.02	<.001
Residual	179	215.813	1.206		
Total	197	590.510			

Odor/Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Testers	8	127.091	15.886	12.56	
Genotypes	10	76.444	7.644	6.04	<.001
Residual	179	226.465	1.265		
Total	197	430.000			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	8	48.1616	6.0202	6.06	
Genotypes	10	106.0909	10.6091	10.69	<.001
Residual	179	177.7273	0.9929		
Total	197	331.9798			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Testers	8	105.101	13.138	8.48	
Genotypes	10	116.091	11.609	7.49	<.001
Residual	179	277.455	1.550		
Total	197	498.646			

Tenderness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Testers	8	65.101	8.138	5.93	
Genotypes	10	91.869	9.187	6.69	<.001
Residual	179	245.677	1.372		
Total	197	402.646			

APPENDICES 5.0: ANOVA TABLES FOR SENSORY EVALUATION WITH FARMERS DURING RATOON CROP

5.1 LOCATION: KIBOKO

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	65.754	7.306	3.84	
Genotypes	11	433.812	39.438	20.72	<.001
Residual	219	416.896	1.904		
Total	239	916.463			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	147.600	16.400	7.18	
Genotypes	11	409.683	37.244	16.32	<.001
Residual	219	499.900	2.283		
Total	239	1057.183			

Odor Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	83.004	9.223	4.82	
Genotype	11	68.746	6.250	3.27	<.001
Residual	219	419.046	1.913		
Total	239	570.796			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	98.671	10.963	5.59	
Genotype	11	167.646	15.241	7.77	<.001
Residual	219	429.479	1.961		
Total	239	695.796			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	116.183	12.909	7.03	
Genotype	11	98.983	8.998	4.90	<.001
Residual	219	402.017	1.836		
Total	239	617.183			

Tenderness'

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	120.100	13.344	6.52	
Genotype	11	74.683	6.789	3.32	<.001
Residual	219	448.400	2.047		
Total	239	643.183			

5.2 LOCATION: KAMBI YA MAWE

Appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	41.933	4.659	2.71	
Genotype	11	124.483	11.317	6.58	<.001
Residual	219	376.767	1.720		
Total	239	543.183			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	86.537	9.615	5.59	
Genotype	11	110.046	10.004	5.82	<.001
Residual	219	376.412	1.719		
Total	239	572.996			

Odor Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	65.754	7.306	3.55	
Genotype	11	46.912	4.265	2.07	0.023
Residual	219	450.796	2.058		
Total	239	563.462			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	25.233	2.804	1.92	
Genotype	11	76.583	6.962	4.76	<.001
Residual	219	320.167	1.462		
Total	239	421.983			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	100.521	11.169	5.58	
Genotype	11	43.446	3.950	1.97	0.032
Residual	219	438.429	2.002		
Total	239	582.396			

Tenderness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Farmer stratum	9	48.417	5.380	2.88	
Genotype	11	99.900	9.082	4.87	<.001
Residual	219	408.683	1.866		
Total	239	557.000			

APPENDICES 6.0: ANOVA TABLES FOR SENSORY EVALUATION WITH PANELISTS DURING RATOON CROP

6.1 LOCATION: KIBOKO

Appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	56.238	9.373	6.61	
Genotype	11	75.208	6.837	4.82	<.001
Residual	150	212.833	1.419		
Total	167	344.280			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	32.738	5.456	4.03	
Genotype	11	81.351	7.396	5.46	<.001
Residual	150	203.190	1.355		
Total	167	317.280			

Odor Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	27.738	4.623	4.17	
Genotype	11	31.018	2.820	2.55	0.006
Residual	150	166.190	1.108		
Total	167	224.946			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	12.9524	2.1587	2.49	
Genotype	11	38.7798	3.5254	4.06	<.001
Residual	150	130.2619	0.8684		
Total	167	181.9940			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	23.726	3.954	2.25	
Genotype	11	51.494	4.681	2.66	0.004
Residual	150	263.631	1.758		

Total	167	338.851			

Tenderness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	7.667	1.278	0.91	
Genotype	11	39.762	3.615	2.58	0.005
Residual	150	209.905	1.399		
Total	167	257.333			

6.2 LOCATION: KAMBI YA MAWE

Appearance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	38.476	6.413	5.93	
Genotype	11	131.732	11.976	11.07	<.001
Residual	150	162.310	1.082		
Total	167	332.518			

Color

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	18.405	3.067	2.56	
Genotype	11	151.405	13.764	11.50	<.001
Residual	150	179.595	1.197		
Total	167	349.405			

Odor Smell

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	45.560	7.593	6.27	
Genotype	11	53.494	4.863	4.01	<.001
Residual	150	181.798	1.212		
Total	167	280.851			

Overall acceptance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	44.8333	7.4722	10.81	
Genotype	11	102.2083	9.2917	13.44	<.001
Residual	150	103.6667	0.6911		
Total	167	250.7083			

Taste

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	65.750	10.958	6.75	
Genotype	11	27.690	2.517	1.55	0.119
Residual	150	243.393	1.623		
Total	167	336.833			

Tenderness

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Technician stratum	6	10.405	1.734	1.29	
Genotype	11	142.048	12.913	9.62	<.001
Residual	150	201.452	1.343		
Total	167	353.905			