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# EFFECT OF DIFFERENT SPACING INTERVALS ON GROWTH AND YIELD OF COWPEA VARIETIES IN KILIFI COUNTY, KENYA

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## ABSTRACT

Cowpea (*Vigna unguiculata* [L.] walp) is an ancient leguminous plant that is indigenous to Africa. It was domesticated in sub-Saharan Africa and is now widely adapted and grown throughout the world. Cowpea is commonly cultivated in the Southern United States, Middle East, Africa, Asia, and throughout the tropics and subtropics. In Kenya, cowpea is the most important grain legume after common beans and pigeon peas. In Kilifi County and the entire Coastal Kenya, cowpea is considered as the most important African leafy vegetable (ALV), being a major source of dietary protein, especially for the rural and urban poor. The major constraints facing cowpea production in Coastal Kenya include unavailability of quality seed, lack of technical packages, low plant population and general lack of awareness of the potential the crop holds in mitigating poverty and malnutrition challenges in the community. A field experiment was carried out at Mtwapa Agricultural Training Centre (ATC) demonstration farm to determine the effect of different spacing intervals on growth and yield of cowpea varieties. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. It consisted of four cowpea varieties namely Ken kunde, Katumani 80 (K80), KVU 27-1 and Machakos 66 (M66) and three spacing intervals (40 cm x 20 cm, 50 cm x 20 cm and 60 cm x 20 cm). The results showed that KVU 27-1 had the highest mean pod length, mean 100 seed weight and mean total seed weight per plot. Machakos 66 had the highest mean above ground biomass whereas Ken Kunde had the highest mean harvest index. It is suggested that cowpea variety KVU 27-1 and spacing interval 50 cm x 20 cm be adopted in cultivation of cowpeas in Kilifi County, for maximum grain yield production.

**Keywords**: Plant density, Spacing interval, Inter-row spacing, Cowpea varieties

## 1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L) Walp) is an important tropical, annual herbaceous grain legume that belongs to the family *Papilionaceae (Fabaceae),* order *Leguminosae* and genus *Vigna*. The genus *Vigna* is made up of over one hundred different species that are widely distributed within the tropics and the sub-tropics, and has great morphological and ecological diversity (Oyewale & Bamaiyi, 2013). The alternate Common names of Cowpea (*Vigna unguiculata* (L) Walp are caupi, southern pea, crowder pea, black eyed pea, yardlong bean, field pea, catjang. The alternate scientific name is *Vigna sinensis* (L.) Savi (Sheahan, 2012). Cowpea is an ancient crop, with the origin and first point of domestication assumed to be Africa but is adapted to different environmental conditions thus grown worldwide. (Agbicodo, Fatokun, Muranaka, Visser & Linden van der, 2009). The estimated area in hectares of cowpeas cultivated world-wide was 14 million in the year 2000 (Hall, 2012). In the year 2010, the Food and Agricultural Organization of the United Nations (FAO) estimated the worldwide production of dry cowpea grains at more than 5.2 million metric tonnes (Oyewale & Bamaiyi, 2013). Globally, 92% of cowpeas are produced in Africa, where it is consumed on a daily basis by approximately 200 million people (Okeyo-Ikawa, Amugune, Njoroge, Asami & Holton, 2016). The main cowpea production areas in Africa are the Sudan Savanna region in North Nigeria as well as the Sahel region (Central Mali, South Niger, Senegal and Sudan). Additionally, significant production has been recorded in the regions of North Eastern Brazil, East and Southern part of Africa and South East Asia (Hall, 2012). The leading producer and consumer of cowpeas worldwide is Nigeria, with an estimated annual production of 2.4 million tons grown on 5 million hectares (Okeyo-Ikawa et al., 2016). During the long rain season, the bulk of cowpeas are grown in regions that are semi-arid, which experience moderate to severe droughts such as the Sudanian Savanna zone, East Africa, North Eastern Brazil and the Sahelian zone (Hall, 2012). Economically, Cowpea is an important and most versatile indigenous legume crop in the continent of Africa, often being referred to as a "hungry-season crop" because it used to be the first crop to be harvested before the cereal crops. It feeds people, their livestock and improves soil fertility because of its ability to fix Nitrogen. Consequently, it helps to increase cereal crops yields when grown in rotation and contributes to the sustainability of cropping systems. Cowpea is grown on small scale basis by millions of African farmers, majority of who are women (Agbicodo et al., 2009). In Kenya, cowpea is one of the most important grain legume after common beans (*Phaseolus vulgaris* L.) and pigeon pea (*Cajanus Cajan* (L.) Mill sp). It is estimated that about 85% of the area under cowpea production is in the arid and semi-arid lands (ASALs) of Eastern Kenya (Kimiti & Jacinta, 2011). The remaining 15% of the cowpea growing area is in Coast, Western and Central Provinces (Kimiti, Odee & Vanlauwe, 2009). According to Kimiti and Jacinta **(**2011), cowpea in Eastern Kenya is intercropped with maize (*Zea mays* L.), common bean (*Phaseolus vulgaris* L.), sorghum (*Sorghum bicolor* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), dolichos (*Lablab purpures* L.) and finger millet (*Eleusine corcana* (L.) Gaertn). Kilifi, one of the counties in Coastal Kenya is ranked as one of the poorest in Kenya with average poverty and food insecurity levels averaging at between 70 and 90%. In Kilifi County and in the entire coastal region of Kenya, cowpea is considered as the most important African leafy vegetable (ALV), being a major source of dietary protein, especially for the rural and urban poor. Lack of technical packages along the entire value chain, unavailability of quality seeds, and the general lack of awareness of the potential of cowpea to mitigate poverty and malnutrition challenges in the community are the major impediments limiting cowpea production in the Coastal Kenya. Cowpea has not received adequate attention in a strongly patriarchal system where the rural communities still view most of the ALVs, cowpea included, as a ‘woman’s’ crop. More attention is now being focussed on support for African leafy vegetables (ALVs) research unlike in the past when it was largely neglected, having been singled out as a key pillar for food and nutrition security strategy and income generation alternative among smallholder farmers in Kenya (Hutchinson, Muniu, Ambuko, Mwakangalu, Mwang’ombe, Okello & Olubayo, 2016).

## 2. MATERIALS AND METHODS

### 2.1 Site Description

***Location of study***

The experiment was carried out at Mtwapa Agricultural Training Centre (ATC) demonstration farm, Mtepeni Ward, Kilifi County between June, 2015 and December, 2015. Mtwapa Agricultural Training Centre is situated about 3 km towards the western side of Mtwapa Town and is about 48 km from Kilifi Town, which is the County headquarter. The area of study lies within an altitude of 30 m above sea level (A.S.L).

***Climate***

The study area is in the coastal lowland agro-ecological zone 3 ($CL_3$) characterized by semi-humid conditions with high relative humidity of more than 80%. The rainfall in Mtepeni ward is bimodal with the long rains starting in April/May up to August and the short rains starting in October and extending to December. Average annual rainfall ranges from 1,050 to 1,230 mm with 66% reliability. Annual temperatures within the study area range between 24.4 – 30°C.

***Soils***

The soils within the area of study are medium sand to loamy medium sand and which are loose to very friable. They are somewhat excessively drained to well drained and very deep (80 – 120 cm thick). The soil colour is yellowish red to yellowish brown. Soil samples from the study area were analysed at National agriculture research laboratories (NARL), Nairobi, Kenya prior to experimentation.

### 2.2 Experimental Procedure

The experiment was laid out as a randomized complete block design (RCBD) with 12 treatment combinations consisting of 4 (four) cowpea varieties and 3 (three) spacing intervals, with three replications. The four cowpea varieties used in the experiment were Ken kunde, Katumani 80 (K80), KVU 27-1 and Machakos 66 (M66), designated as $V_1$, $V_2$, $V_3$ and $V_4$ respectively. The 3 (three) spacing intervals used were 40 cm x 20 cm, 50 cm x 20 cm (Control) and 60 cm x 20 cm, designated as $S_1$, $S_2$ and $S_3$ respectively.

The land was first cleared and ploughed to medium tilth both by tractor and by hand.

Three blocks, each measuring 3 m wide and 50 m long with 2 m paths between them were laid out using a tape measure, pegs and sisal twine. Each of the three blocks was divided into 12 plots measuring 3 m by 3 m with a 1 m path separating each plot from the other, achieving a total of 36 plots.

The Four (4) cowpea varieties were planted at a depth of 4-5 cm as per the treatment combinations stated in table 2.2. TSP fertilizer was applied according to the agronomic recommendation of 20 kg of $P_2O_5$ $ha^{-1}$and the experimental plots kept weed free by manual weeding. Five (5) cowpea plants were randomly selected and pre-tagged in each of the plots, excluding the border rows for the purpose of data collection. The parameters investigated include plant height, number of branches, number of pods per plant, pod length, number of seeds per pod, 100 seed weight, seed weight per plant, above ground biomass, seed weight per plot and harvest index

### 2.3 Treatments and Treatment Combinations

**i. Treatment**

**Spacing**

40 x 20 cm …….. $S_1$

50 x 20 cm …… $S_2$ (Control)

60 x 20 cm ……. $S_3$

**Cowpea varieties**

Ken kunde …………. $V_1$

| | | |
|---|---|---|
| Katumani 80 (K80) | …………..... | $V_2$ |
| KVU 27-1 | ………….. | $V_3$ |
| Machakos 66 (M66) | ……….…... | $V_4$ |

**ii. Treatment Combinations**

| | **Factor 1 (Variety)** | | | |
|---|---|---|---|---|
| **Factor 2 (Spacing)** | **$V_1$** | **$V_2$** | **$V_3$** | **$V_4$** |
| **$S_1$** | $S_1V_1$ | $S_1V_2$ | $S_1V_3$ | $S_1V_4$ |
| **$S_2$** | $S_2V_1$ | $S_2V_2$ | $S_2V_3$ | $S_2V_4$ |
| **$S_3$** | $S_3V_1$ | $S_3V_2$ | $S_3V_3$ | $S_3V_4$ |

**Table 2.2: Spacing and Variety Combinations**

## 2.4 Plot Layout

After the land was cleared and ploughed to medium tilth, three blocks, each measuring 3 m wide and 50 m long with 2 m paths between them were laid out using a tape measure, pegs and sisal twine. Each of the three blocks was divided into 12 plots measuring 3 m by 3 m with a 1 m path separating each plot from the other, achieving a total of 36 plots. The result was as shown in figure 2.1.

**Block 1**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_2V_2$ | $S_1V_1$ | $S_3V_3$ | $S_3V_4$ | $S_1V_2$ | $S_3V_1$ | $S_2V_4$ | $S_1V_3$ | $S_2V_3$ | $S_3V_2$ | $S_2V_1$ | $S_1V_4$ |

**Block 2**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_2V_3$ | $S_1V_4$ | $S_2V_2$ | $S_3V_3$ | $S_1V_1$ | $S_3V_2$ | $S_1V_3$ | $S_3V_4$ | $S_3V_1$ | $S_2V_4$ | $S_1V_2$ | $S_2V_1$ |

**Block 3**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_3V_3$ | $S_1V_2$ | $S_2V_4$ | $S_3V_1$ | $S_2V_2$ | $S_3V_4$ | $S_1V_1$ | $S_2V_3$ | $S_3V_2$ | $S_1V_4$ | $S_2V_1$ | $S_1V_3$ |

**Figure 2.1: Plot Layout**

## 2.5 Data Collection

i. Plant height was monitored on a fortnightly basis. Measurements of the main stem from the base to the highest tip of the plant were taken from each of the five (5) randomly selected and pre-tagged plants per plot using a tape measure.

ii. Number of branches per plant was obtained by counting the number of primary reproductive branches from each of the five (5) randomly selected and pre-tagged plants per plot at maturity.

iii. Number of pods per plant from the five (5) randomly selected and pre-tagged plants per plot was determined through counting at harvest.

iv. Pod length from each of the five (5) randomly selected and pre-tagged plants per plot was determined by measuring with a 30 cm ruler at harvest.

v. Number of seeds per pod from the five (5) randomly selected and tagged plants per plot was determined through counting at harvest.

vi. 100-seed weight was estimated at harvest by counting 100 seeds at random from each plot and weighing them using an electronic balance.

vii. Seed weight per plant was determined at harvest from each of the five (5) randomly selected and pre-tagged plants per plot using an electronic balance.

viii. The above ground biomass was determined by harvesting each of the five (5) randomly selected and pre-tagged plants per plot at physiological maturity and their dried biomass (from base to the highest tip) determined using an electronic weighing balance.

ix. Seed weight per plot was determined at harvest using an electronic weighing balance.

x. Harvest index *(HI)* is the ratio of grain yield to total biomass yield. Harvest index (HI) was determined by dividing the total seed yield per plant by the above ground biomass per plant of each of the five (5) randomly selected and pre-tagged plants per plot. The formula used to compute the *Harvest index* ***(%)*** *is as* follows:-

$$\text{Harvest index } (\%) = \frac{\text{Total seed yield per plant}}{\text{Above ground biomass per plant}} \times 100$$

## 2.6 Data Analysis

i. The data collected was summarized using excel package after which it was analysed using SPSS version 22.
ii. Analysis of variance (ANOVA) was carried out at 0.05 significance level to determine whether there were significant differences
iii. Where ANOVA indicated significant differences between the means, then Post-Hoc test was carried out to determine where the differences were.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Plant Height

Plant height was monitored on a fortnightly basis from the date of sowing. Measurements of the main stem from the base to the highest tip of the plant were taken using a tape measure. The results were as shown in Figures 3.1 and 3.2.

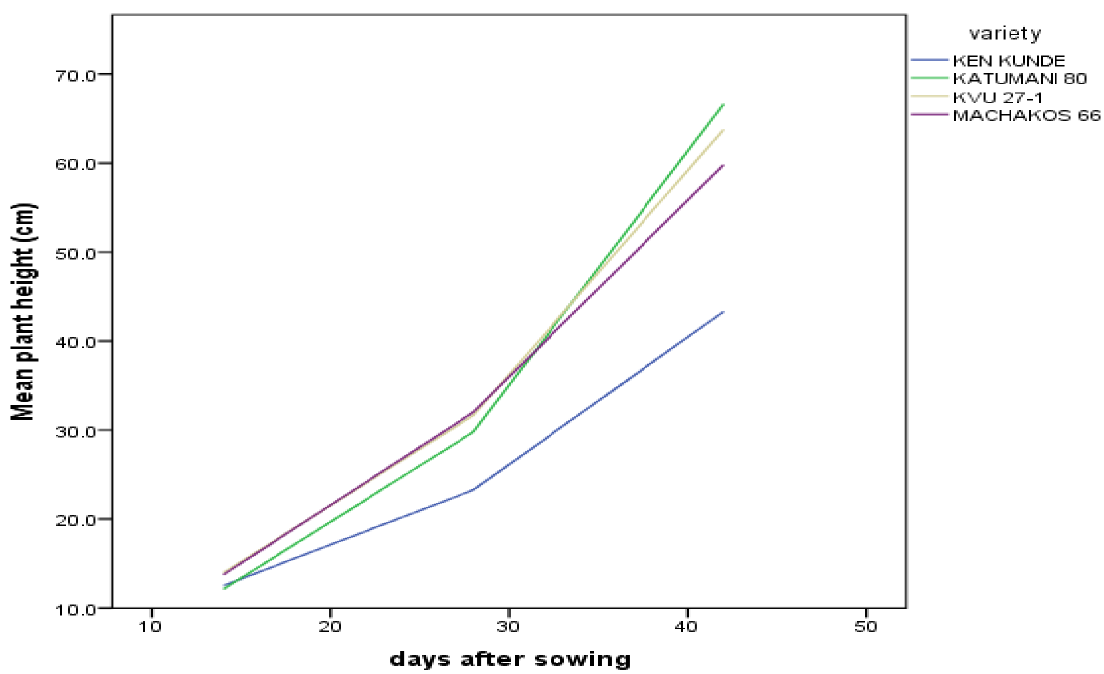


**Figure 3.1: Average plant height in relation to days of sowing**

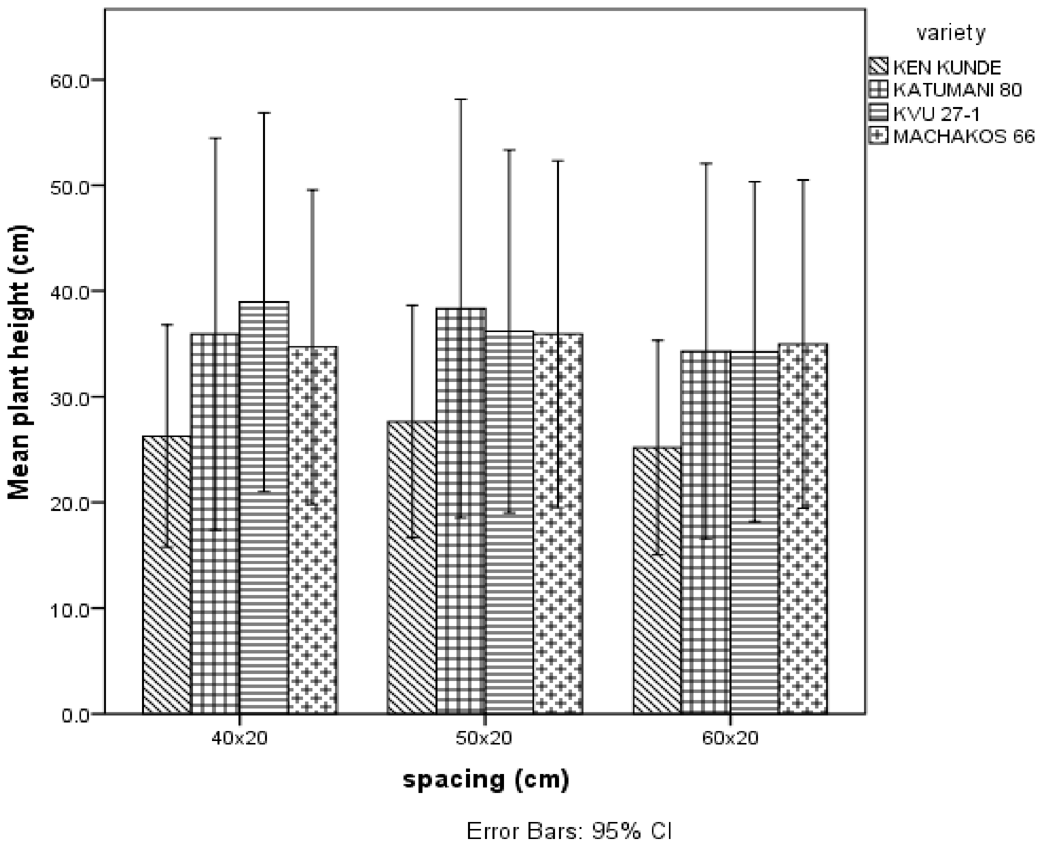


**Figure 3.2: Mean plant height at different spacing intervals**

Plant height was affected by the planting density. There was a general increase in plant height at the narrow spacing intervals of 40x20 cm and 50x20 cm in comparison to the wider spacing interval of 60x20 cm (Figure 3.2). Katumani 80 (K80) attained the highest plant height followed by KVU 27-1and Machakos 66. Ken Kunde attained the lowest plant height (Figure 3.1 and Figure 3.2).The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were no significant differences ($p>0.05$) for plant height between the treatments hence no need for Post hoc test. The general increase in plant height at the narrow inter-row spacing intervals could be attributed to competition for light and space. Similar observations were reported in a study by El Naim and Jabereldar (2010).They observed that increased plant densities led to increase in plant height.

### 3.2 Number of Branches

The number of branches per plant was obtained at maturity by counting the number of primary reproductive branches. The results were as shown in Figure 3.3

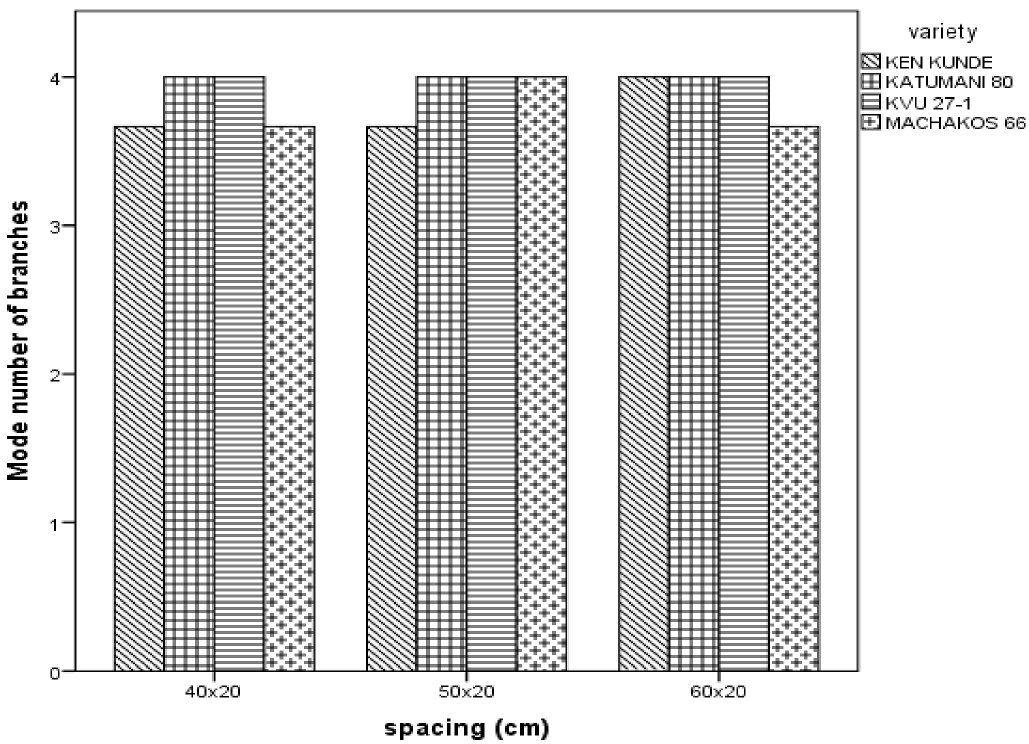


**Figure 3.3: The mode number of branches at different spacing intervals**

Generally, the mode number of branches was higher at the wider spacing intervals of 50x20cm and 60x20cm with an exception of one variety in each. At the narrow spacing interval of 40x20cm, a lower number of branches was recorded compared to the case in the wider spacing interval (Figure 3.3).The analysis of variance (ANOVA) at $\alpha$=0.05 indicated there were no significant differences ($p>0.05$) for number of branches between the treatments hence no need for Post hoc test. The decline in the number of branches at the narrowest inter-row spacing interval (40x20cm) could be attributed to limitation of space. Similar observations were reported in a study by El Naim and Jabereldar (2010).They observed that increased plant densities reduced the number of branches per plant.

### 3.3 Number of Pods per Plant

The number of pods per plant was determined at harvest through counting. The results were as shown in Figure 3.4

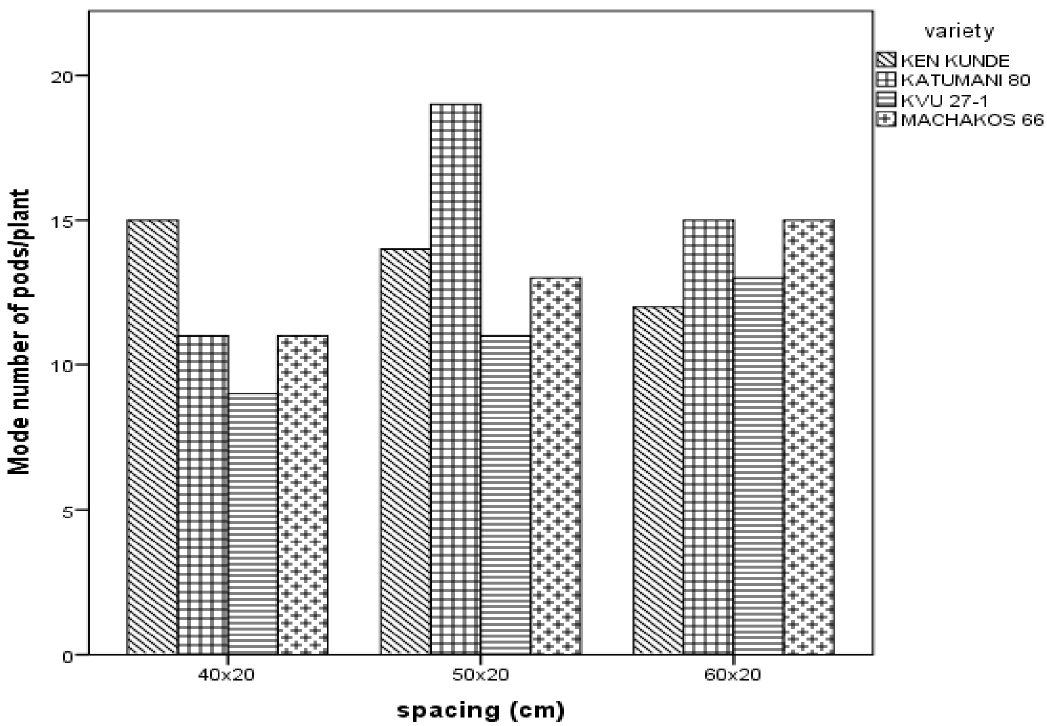


**Figure 3.4: The mode number of pods per plant at different spacing intervals**

Comparatively, the number of pods per plant was higher at the wider inter-row spacing of 50x20cm and 60x20cm than at the narrow spacing interval of 40x20cm **(**Figure 3.4). The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were no significant differences ($p>0.05$) for the number of pods per plant between treatments hence no need for a Post hoc test. The reduction in number of pods per plant with decrease in plant spacing could be attributed to the interference among branches. Similarly, enhanced mutual shading could have led to increased abortion of reproductive parts in the lower canopy layer in the densely populated plants. This agrees with earlier findings by Jakusko et al. (2013) that increase in spacing significantly increased the number of pods per plant.

### 3.4 Pod Length

The pod length was determined at harvest by measuring with a 30 cm ruler. The results were as shown in Figure 3.5

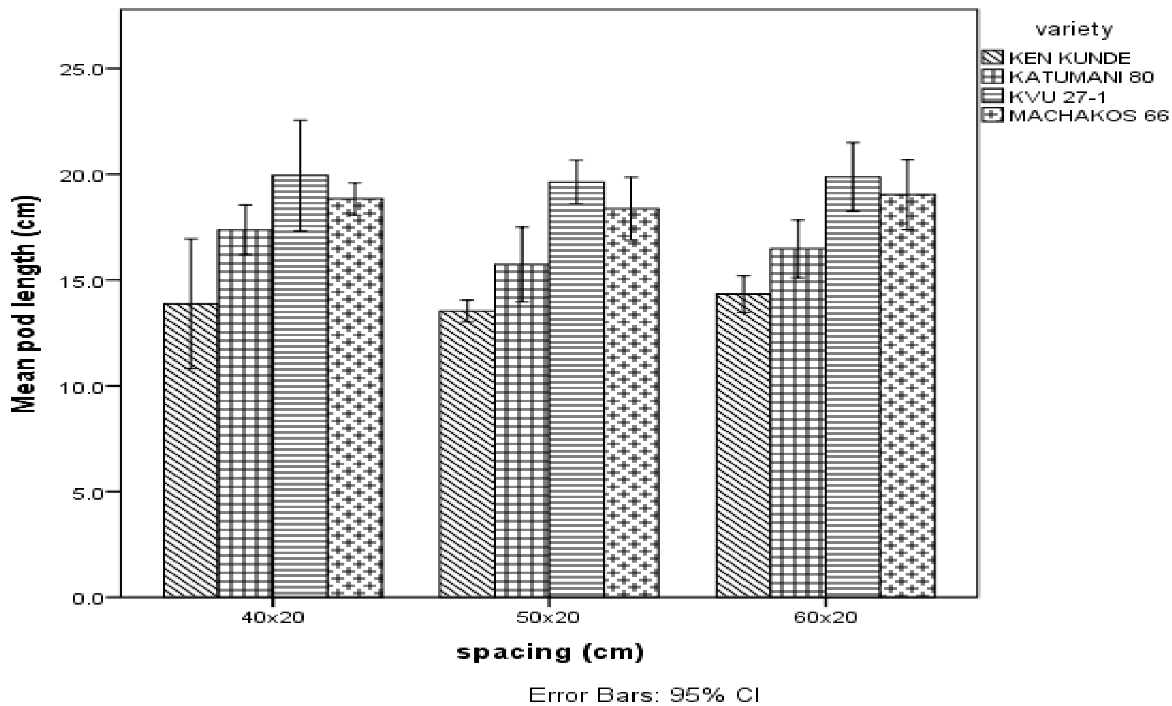


**Figure 3.5: The mean pod length at different spacing intervals**

The mean pod length exhibited a similar trend across the spacing intervals. The varieties responded similarly to plant density (Figure 3.5).

The analysis of variance (ANOVA) at α=0.05 indicated there were significant differences ($p<0.05$) in the mean pod length for different treatments. A Post hoc test was done to find out where the differences were and the results are as shown in Table 3.1 for Variety and Table 3.2 for Spacing

**Table 3.1: LSD summary for mean Pod length**

| Variety | Machakos 66 | KVU 27-1 | Katumani 80 | Ken Kunde |
|---|---|---|---|---|
| Machakos 66 | | -1.067* | 2.222* | 4.833* |
| KVU 27-1 | | | 3.289* | 5.900* |
| Katumani 80 | | | | 2.611* |
| Ken Kunde | | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.1 at p<0.05, it can be concluded there were significant differences in the mean pod length between variety Machakos 66 and KVU 27-1 , Machakos 66 and Katumani 80 and also between Machakos 66 and Ken Kunde. Significant differences were also observed between KVU 27-1 and Katumani 80, KVU 27-1 and Ken Kunde and finally between Katumani 80 and Ken Kunde. Mean pod length was highest in variety KVU 27-1 followed by Machakos 66 and then Katumani 80. Ken Kunde had the lowest mean pod length. The variation among varieties could be due to the growth habit and the genetic potential of each genotype. Similar observations were reported in a study by Nwofia, Nwanebu and Mbah (2014) who found that variations among varieties could be due to transferable parental trait differences as well as environmental influence.

**Table 3.2: LSD summary for mean Pod length**

| Spacing | 40x20 | 50x20 | 60x20 |
|---|---|---|---|
| 40x20 | | .683* | .075 |
| 50x20 | | | -.608* |
| 60x20 | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.2 at p<0.05, it can be concluded there were significant differences in the mean pod length between spacing 40x20 cm and 50x20 cm and also between 50x20 cm and 60x20 cm. There were no significant differences between 40x20 cm and 60x20 cm. The mean pod length was higher at the spacing interval of 40x20 cm followed by the spacing interval 60x20 cm. The mean pod length at the spacing interval of 50x20 cm was the lowest. The variations observed could be due to the growth habit and the genetic potential of each genotype as well as environmental influence. This agrees with previous findings by Satodiya et al. (2015), who reported that planting density did not affect the average pod length.

### 3.5 Number of Seeds per Pod

The Number of seeds per pod was determined at harvest through counting.The results were as as shown in Figure 3.6

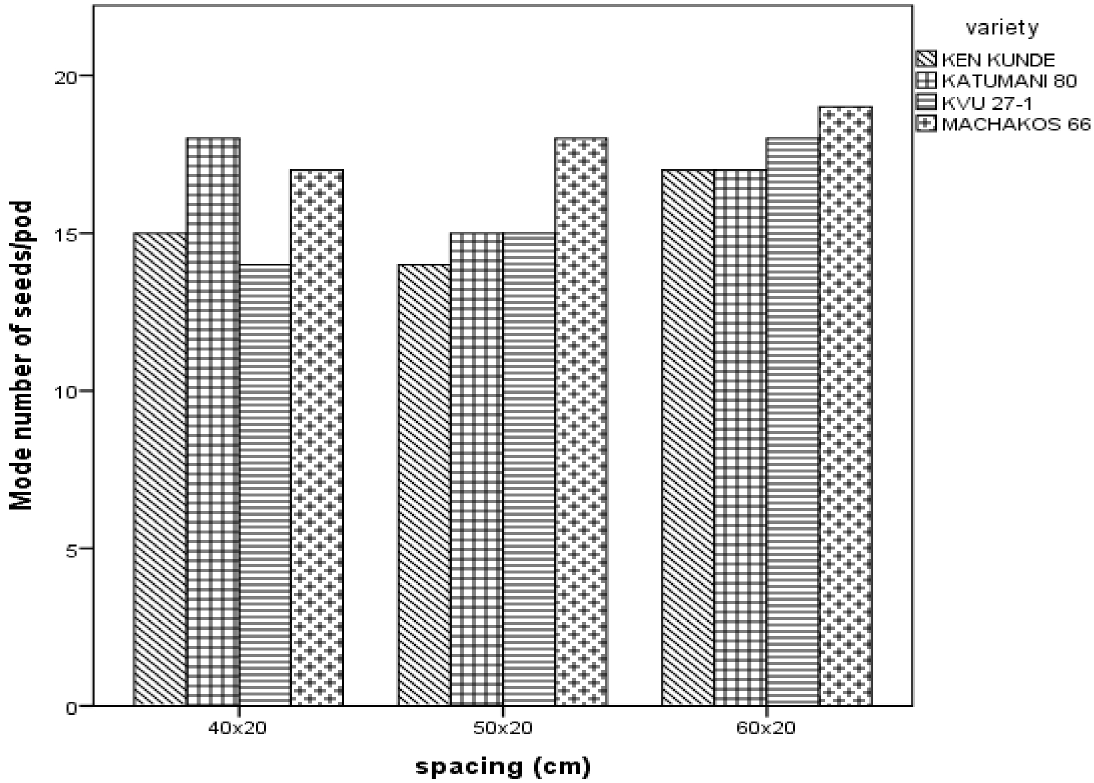


**Figure 3.6: The mode number of seeds per pod at different spacing intervals**

Generally, the mode number of seeds per pod was higher at the wider inter-row spacing interval of 60x20cm (Figure 3.6). The analysis of variance (ANOVA) at $\alpha$=0.05 indicated there were no significant differences ($p>0.05$) for mode number of seeds per pod between the treatments hence no need to carry out a post Hoc test. Decrease in plant density (increase in plant spacing) led to increase in the number of seeds per pod. This increase could be due to lower rate of seed abortion as opposed to the case in closely spaced plants. These results are in close conformity with the findings of El Naim and Jabereldar (2010).

### 3.6: 100 Seed Weight

The 100-seed weight was estimated at harvest by counting 100 seeds at random and weighing them using an electronic balance. The results were as shown in Figure 3.7

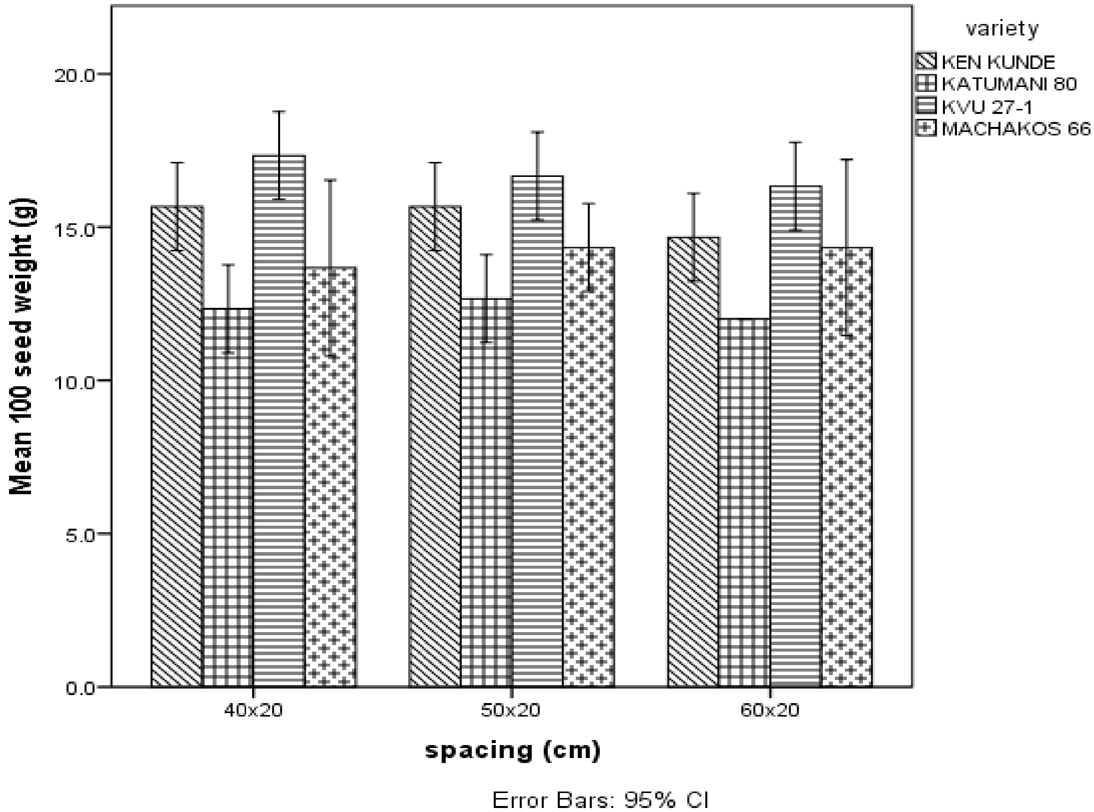


**Figure 3.7: The mean100 seed weight at different spacing intervals**

The mean 100 seed weight trend was similar across the spacing intervals. The varieties responded similarly to plant density (Figure 3.7). The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were significant differences ($p<0.05$) in the mean 100 seed weight for different treatments. A Post hoc test was done to find out where the differences were and the results are as shown in Table 3.3 for Variety.

**Table 3.3: LSD summary for mean 100 Seed Weight**

| Variety | Machakos 66 | KVU 27-1 | Katumani 80 | Ken Kunde |
|---|---|---|---|---|
| **Machakos 66** | | **-2.667*** | **1.778*** | **-1.222*** |
| **KVU 27-1** | | | **4.444*** | **1.444*** |
| **Katumani 80** | | | | **-3.000*** |
| **Ken Kunde** | | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.3 at p<0.05, it can be concluded there were significant differences in the mean 100 seed weight between variety Machakos 66 and KVU 27-1 , Machakos 66 and Katumani 80 and also between Machakos 66 and Ken Kunde. Significant differences were also observed between KVU 27-1 and Katumani 80, KVU 27-1 and Ken Kunde and finally between Katumani 80 and Ken Kunde**.** Mean 100 seed weight was greatest in variety KVU 27-1 followed by Ken Kunde and then Machakos 66. Katumani 80 had the lowest mean 100 seed weight. The variation among varieties could be due to the growth habit and the genetic potential of each genotype. Similar observations were reported in a study by Jakusko et al. (2013).

### 3.7 Seed weight per Plant

The seed weight per plant was determined at harvest using an electronic balance.The results were as shown in Figure 3.8

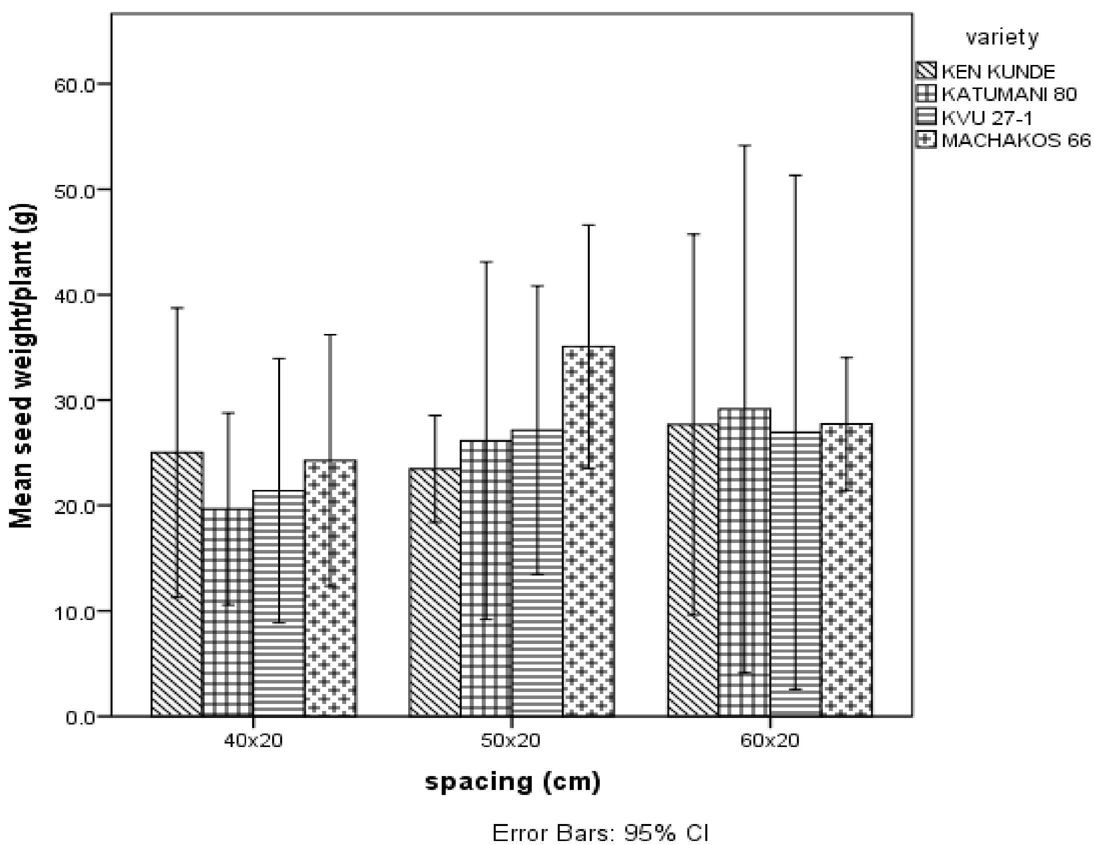


**Figure 3.8: The mean seed weight per plant at different spacing intervals**

There was a general increase in mean seed weight per plant with increase in inter-row spacing (Figure 3.8). The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were no significant differences ($p>0.05$) for mean seed weight per plant between the treatments hence no need to carry out a post Hoc test. The increase in mean seed weight per plant with increase in inter-row spacing could be due to less competition for nutrients in wider spaced plants. This agrees with earlier findings by El Naim and Jabereldar (2010) that increasing plant population decreased seed yield per plant.

**3.8 Above Ground Biomass**

The above ground biomass was determined by harvesting the plant (from base to the highest tip) at physiological maturity and weighing the dried biomass using an electronic weighing balance. The results were as shown in Figure 3.9

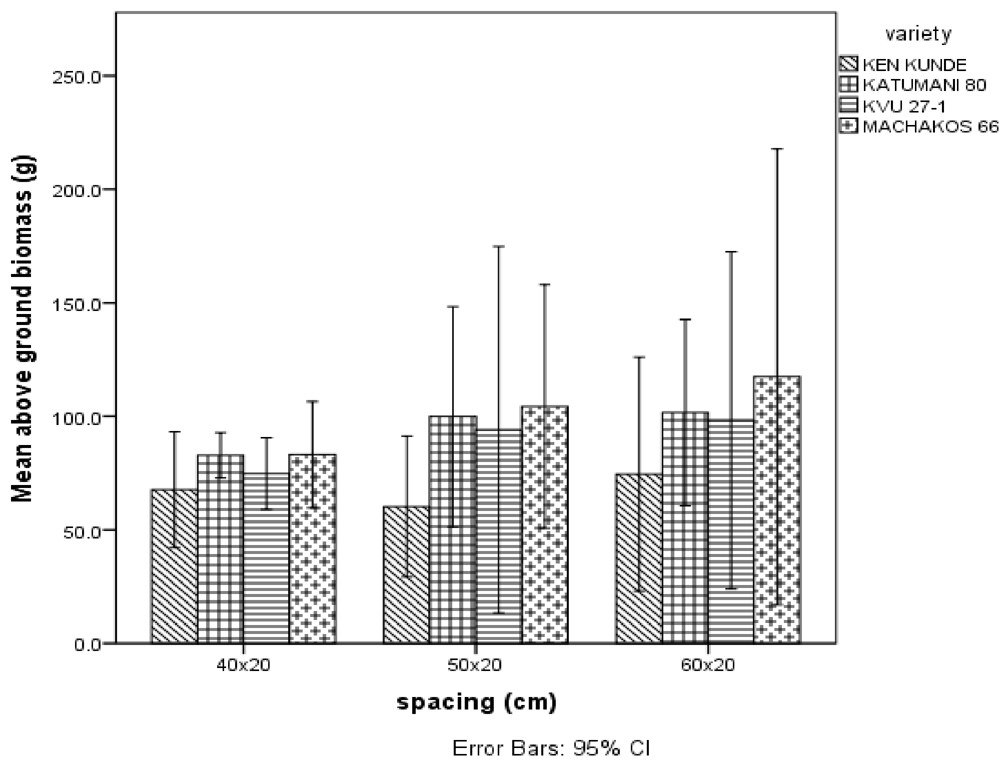


**Figure 3.9: The mean above ground biomass at different spacing intervals**

There was a general increase in mean above ground biomass with increase in inter - row spacing interval (decrease in plant population) Figure 3.9.The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were significant differences ($p<0.05$) in the mean above ground biomass for different treatments. A Post hoc test was done to find out where the differences were and the results are as shown in Table 3.4 for Variety and Table 3.5 for Spacing.

**Table 3.4: LSD summary for mean above ground biomass**

| Variety | Machakos 66 | KVU 27-1 | Katumani 80 | Ken Kunde |
|---|---|---|---|---|
| Machakos 66 | | 12.600 | 6.867 | 34.156* |
| KVU 27-1 | | | -5.733 | 21.556* |
| Katumani 80 | | | | 27.289* |
| Ken Kunde | | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.4 at $p<0.05$, it can be concluded there were significant differences in the mean above ground biomass between variety Machakos 66 and Ken Kunde, KVU 27-1 and Ken Kunde and also between Katumani 80 and Ken Kunde. There were no significant differences between Machakos 66 and KVU 27-1, Machakos 66 and Katumani 80 and finally between KVU 27-1 and Katumani 80. The mean above ground biomass was greatest in variety Machakos 66 followed by Katumani 80 and then KVU 27-1. Ken Kunde had the lowest mean above ground biomass. The variation among varieties could be due to the growth habit and the genetic potential of each genotype. Similar observations were reported in a study by Nwofia et al. (2014).

**Table 3.5: LSD summary for mean above ground biomass**

| Spacing | 40x20 | 50x20 | 60x20 |
|---|---|---|---|
| 40x20 | | -12.567 | -20.850* |
| 50x20 | | | -8.283 |
| 60x20 | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.5 at p<0.05, it can be concluded there were significant differences in the mean above ground biomass between spacing 40x20 cm and 60x20 cm. There were no significant differences between 40x20 cm and 50x20 cm, and between 50x20 cm and 60x20 cm. The mean above ground biomass for spacing interval 60x20 cm was higher than for 50x20 cm. The mean above ground biomass for 40x20 cm was the lowest. The increase in the mean above ground biomass with increase in spacing could be attributed to less completion for space, nutrients and light compared to the case in the closely spaced plants. This agrees with previous findings by Nwofia et al. (2014) who observed increase in dry matter per plant with increase in spacing.

**3.9 Total Seed Weight per Plot**

The total seed weight per plot was determined at harvest using an electronic weighing balance. The results were as shown in Figure 3.10

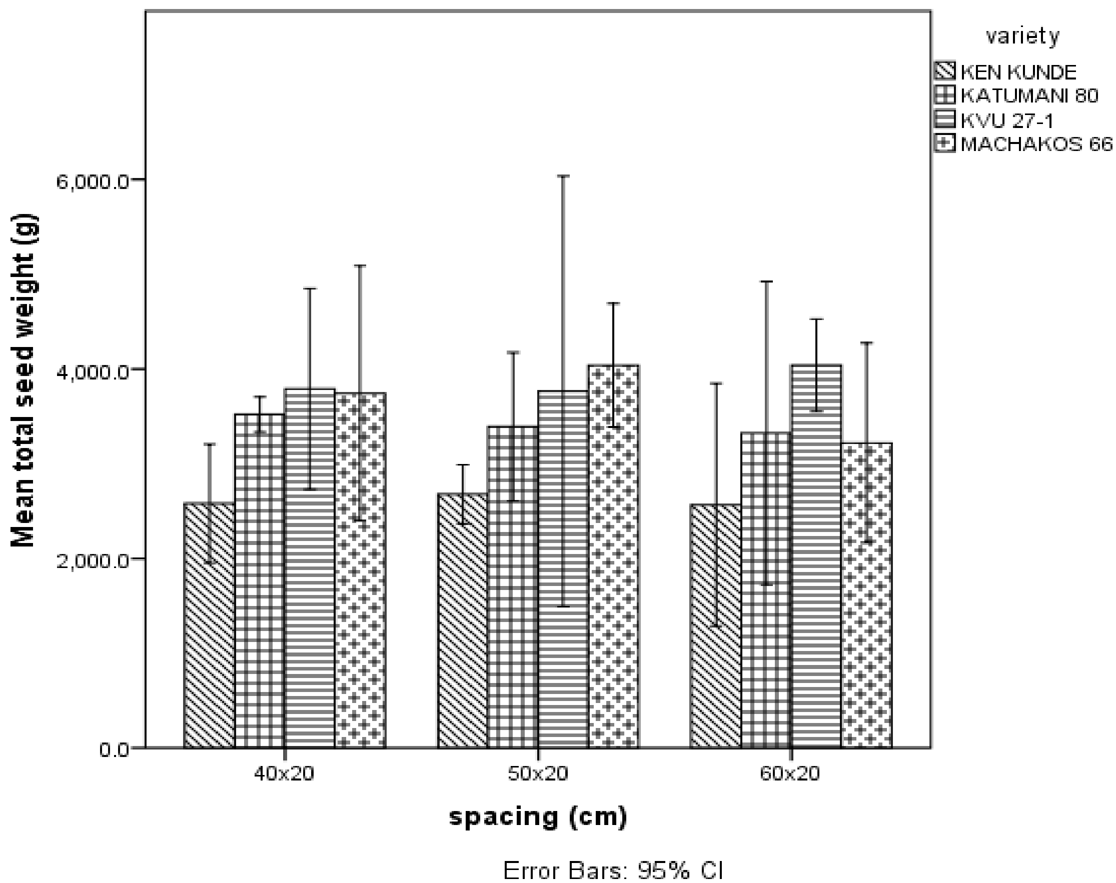


**Figure 3.10: The mean total seed weight per plot at different spacing intervals**

Comparatively, there was a general increase in mean total seed weight with decrease in inter-row spacing (Figure 3.10). The analysis of variance (ANOVA) at α=0.05 indicated there were significant differences ($p<0.05$) in the mean total seed weight for different treatments. A Post hoc test was done to find out where the differences were and the results are as shown in Table 3.6 for varieties.

**Table 3.6: LSD summary for total Seed weight per plot**

| Variety | Machakos 66 | KVU 27-1 | Katumani 80 | Ken Kunde |
|---|---|---|---|---|
| **Machakos 66** | | -197.000 | 255.667 | 1058.889* |
| **KVU 27-1** | | | 452.667* | 1255.889* |
| **Katumani 80** | | | | 803.222* |
| **Ken Kunde** | | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.6 at $p<0.05$, it can be concluded there were significant differences in the mean total seed weight between variety Machakos 66 and Ken Kunde, KVU 27-1 and Katumani 80, KVU 27-1 and Ken Kunde, and also between Katumani 80 and Ken Kunde. There were no significant differences between Machakos 66 and KVU 27-1 and finally between Machakos 66 and Katumani 80. The mean total seed weight was greatest in variety KVU 27-1 followed by Machakos 66 and then Katumani 80. Ken Kunde had the lowest mean total seed weight. The variation among varieties could be due to the growth habit and the genetic potential of each genotype as well as variation in leaf area index. Similar observations were reported in a study by Kamara, Tofa, Kyei-Boahen, Solomon , Ajeigbe and Kamai (2016) who found out that high plant density increases light interception, dry matter and yield components (pods and seeds).

### 3.10 Harvest Index

The harvest index (HI) was determined by dividing the total seed yield per plant by the above ground biomass per plant and expressing it as a percentage. The results were as shown in Figure 3.11

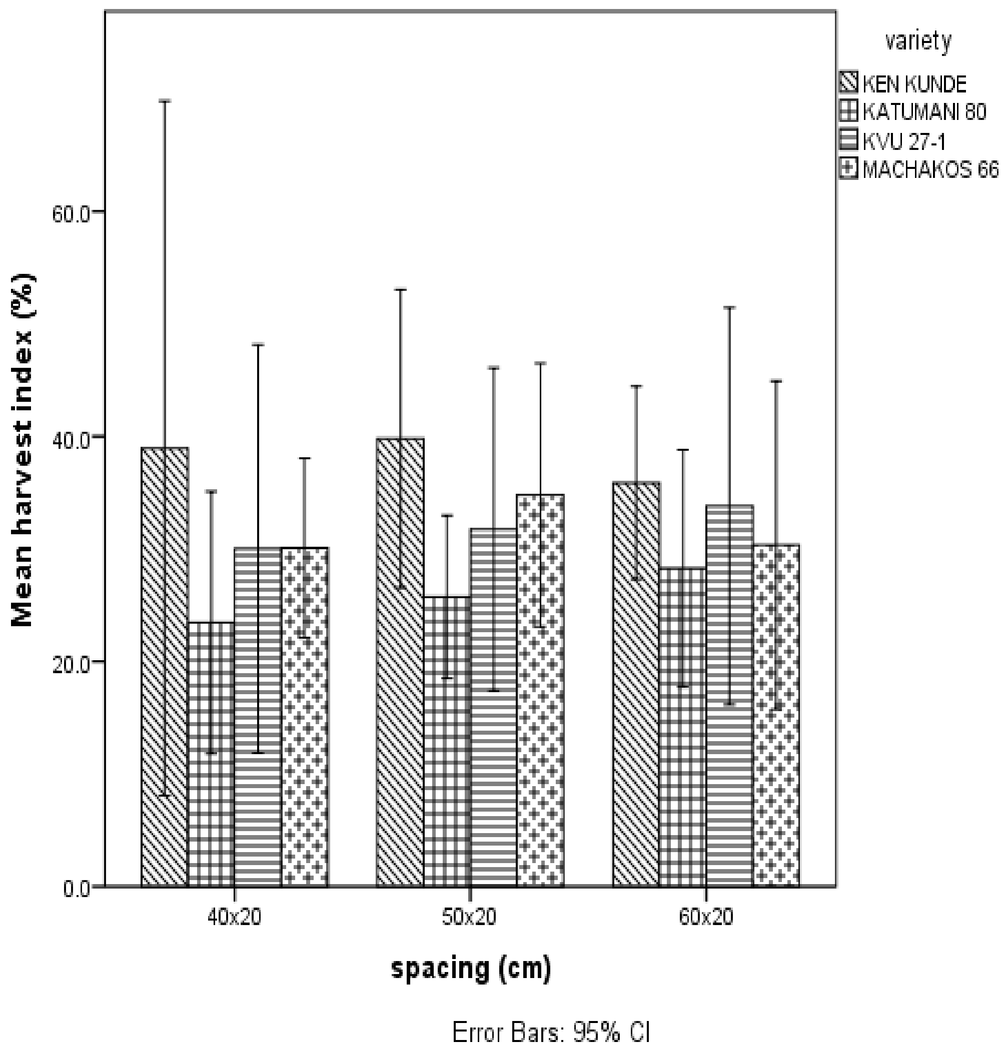


**Figure 3.11: The mean harvest Index at different spacing intervals**

The mean harvest index registered a general increase at first but later declined for some varieties with increase in inter-row spacing (Figure 3.11). The analysis of variance (ANOVA) at $\alpha=0.05$ indicated there were significant differences ($p<0.05$) in the mean harvest index for the different treatments. A Post hoc test was done to find out where the differences were and the results are as shown in Table 3.7 for varieties.

**Table 3.7: LSD summary for Harvest Index**

| Variety | Machakos 66 | KVU 27-1 | Katumani 80 | Ken Kunde |
|---|---|---|---|---|
| **Machakos 66** | | -.111 | 5.911* | -6.467* |
| **KVU 27-1** | | | 6.022* | -6.356* |
| **Katumani 80** | | | | -12.378* |
| **Ken Kunde** | | | | |

***. The mean difference is significant at the 0.05 level.**

From the LSD summary, Table 3.7 at p<0.05, it can be concluded there were significant differences in the mean harvest index between variety Machakos 66 and Katumani 80, Machakos 66 and Ken Kunde, KVU 27-1 and Katumani 80, KVU 27-1 and Ken Kunde and also between Katumani 80 and Ken Kunde. There were no significant differences between Machakos 66 and KVU 27-1. The mean harvest index was greatest in variety Ken Kunde followed by KVU 27-1 and Machakos 66. Katumani 80 had the least mean harvest index. The variation among varieties could be due to the growth habit and the genetic potential of each genotype. Similar results were obtained by Jakusko et al. (2013) who reported that cowpea cultivars had a highly significant effect on harvest index since they differ in the partitioning of assimilates to the grain.

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusions

The study showed that there were statistically significant differences between the treatment means ($P < 0.05$) for pod length, 100 seed weight, above ground biomass, total seed weight per plot and harvest index. KVU 27-1 had the highest mean pod length, mean 100 seed weight and mean total seed weight per plot. Machakos 66 had the highest mean above ground biomass whereas Ken Kunde had the highest mean harvest index.

The highest mean pod length was realized at the spacing interval of 40cm x20 cm and the highest mean above ground biomass at the spacing interval of 60cm x20 cm. There were no significant differences between treatment means (P >0.05) on plant height, number of branches, number of pods per plant, number of seeds per pod and seed weight per plant.

**4.2 Recommendations**

From the study, the following recommendations can be made;

When cowpea is grown with pod length as the motive, the spacing interval of 40cm x20 cm is recommended whereas the spacing interval of 60cm x20 cm is recommended when above ground biomass is the motive. Cowpea variety KVU 27-1 is recommended for maximum cowpea grain yield in Kilifi County.

More research work should be carried out on the effect of different spacing intervals on growth and yield of cowpea varieties.

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