Evaluating Productivity of Three Legume Species at Different Agro-ecological Zones of Makueni County Kenya

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Abstract

Grain legume production in Makueni County is low mainly due to drought. Drought tolerant legumes can be used to mitigate the effects of drought as well as improving soil fertility through biological nitrogen fixation and as green manure. The objective of the study was to evaluate the productivity of three legume species in different agro-ecological zones in Makueni County. This study was conducted in Makueni County during the 2014 long rain from March to July season in three locations namely Machinery Inner Lowland 6 (IL6), Utafiti Lower Midland 5(LM5) and Mwanzo Lower Midland 4 (LM4) with five farmers from each location. The three legume species were Beans (KAT/B-9), Cowpea (M66), Lablab (KAT/DL-1) and Lablab accession CP1 81364. The experiment was laid out as a Randomised Complete Block Design (RCBD) with five replications. Data was collected on biomass yield at physiological maturity and grain yield at harvest. Data was subjected to ANOVA using SAS. There was no significant difference ($P \leq 0.05$) in the biomass and grain yields of KAT Bean 9 across the three locations. However, cowpea and lablab yields were significantly ($P \leq 0.05$) different across the locations. Cowpea M66 biomass and grain yields were significantly ($P \leq 0.05$) higher in Mwanzo as compared to the other locations. The biomass yield was 2840 kg/ha while grain yield was 1823 kg/ha. Lablab biomass and grain yields were significantly ($P \leq 0.05$) higher in Utafiti and Mwanzo locations than Machinery. KAT/DL-1 biomass yields was 3856 kg/ha and 4012 kg/ha in Utafiti and Mwanzo respectively. The grain yields in Utafiti and Mwanzo were 1604 kg/ha and 1823 kg/ha respectively. Overall, lablab variety KAT/DL-1 significantly ($P \leq 0.05$) yielded more biomass and grain than CP1 81364 across the three locations. The results show that KAT Bean-9 was suitable in the three agro-ecological zones. Cowpea variety M66 is more suited to LM4 agro-ecological zone while lablab variety KAT/DL-1 is suitable for LM4 and LM5 agro-ecological zones. Farmers should cultivate legume varieties better adapted to their agro-ecological zones to improve yields.

Keywords: Beans, cowpea, lablab, agro-ecological zone, Makueni County.

INTRODUCTION

Grain legumes are important to both man and livestock. They can be utilized as food, fodder, green manure and cover crops (Kimiti *et al.,* 2009). They can also improve soil fertility through biological nitrogen fixation (Chianu *et al.,* 2011). In Kenya, different types of grain legumes are grown in various parts of the country. The most common grain legumes cultivated in Makueni County are beans (*Phaseolus vulgaris* L.), cowpea (*Vigna unguiculata* (L.) Walp), pigeon peas (*Cajanus cajan* (L.) Millsp), and green grams (*Vigna radiata* Wilczek) (Wambua *et al.,* 2014).

Makueni County is one of the main grain legume producing counties in Kenya. However, legume productivity in the County remains far lower than the potential (Mwangangi *et al.,* 2012). This is mainly caused by drought and moisture stress (Kimiti *et al.,* 2009). Drought accounts for up to 50 % yield loss of legumes in Makueni County (Okwiri *et al.,* 2009). Drought tolerant legume varieties have been developed that can do well in the area. However, their suitability to the various agro-ecological zones of Makueni County remains unknown (Karugia *et al.,* 2012).

MATERIALS AND METHODS

Description of research area

The research was conducted in Makueni County. It stretches from latitude 1º35´S to 3º01´S from North to South and from longitudes 37º10´E and 38º30´E from East to West. It has an area of 8,009 km^2, about 70% being arid and semi arid lands (Makueni County report, 2013).

Majority of Makueni County lies within agro-ecological zone 5 (AEZ 5) in the semi-arid region of Eastern Kenya (Jaetzold *et al.,* 2010). Highly weathered soils (Ferralsols, Acrisols and Luvisols) dominate the area. The area receives mean annual rainfall of 231 mm and 361 mm during long (March to July) and short rain seasons respectively (Recha *et al.,* 2012). The mean maximum temperature of the area is 25°C and the mean minimum temperature is 13°C (Jaetzold *et al.,* 2010).

Site and farmer selection

The study was conducted in three locations selected across Makueni County based on the different agro-ecological zones. The first location was at Machinery which is in the inner lowland ranching zone (IL 6). The other location was at Utafiti which is in the lower midland livestock-millet zone (LM 5). The third location was at Mwanzo which is in the Lower Midland marginal cotton zone (LM 4). From each location, five smallholder farmers that rely on farming activities as their first income source were selected to participate in the study.

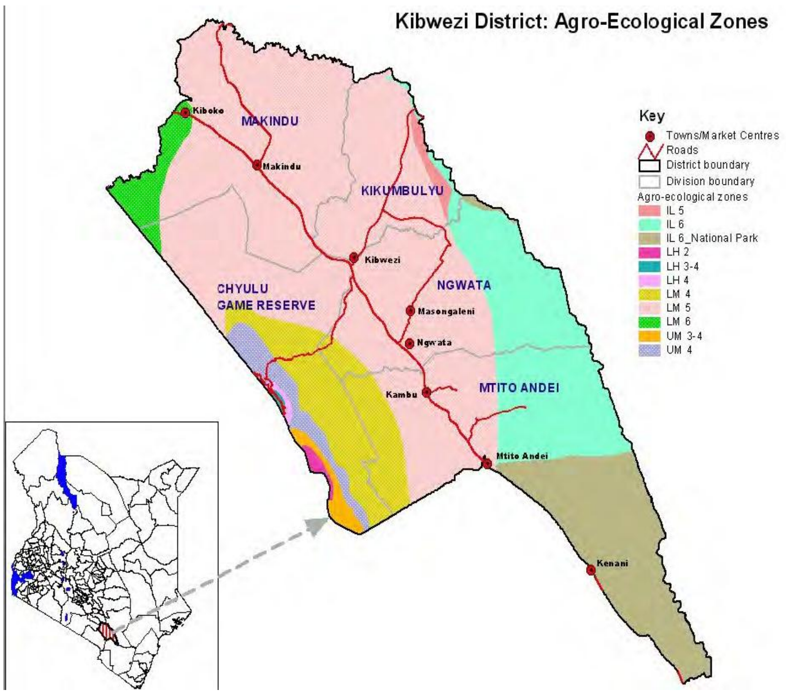

Figure 1: Map of Makueni County, Kenya showing different Agro-Ecological Zones (Map adapted from Bishaw *et al.*, 2013)

Experimental Design, treatments and crop husbandry

The experiment was carried out from March to July, 2014 during the long rainy season. The field experiments were laid out in a Randomized Complete Block Design and in a factorial arrangement with five replications per location. Each location had five farmers with one block per farm. The experimental units measured 5 metres by 3 metres separated by 1 metre paths. The three legume species were Beans (KAT/B-9), Cowpea (M66), Lablab (KAT/DL-1) and Lablab accession CP1 81364. The legume varieties selected were well adapted to the climatic conditions of the study area (Karanja *et al.*, 2006; Karugia *et al.*, 2012).

The experimental sites were cleared and all the ground vegetation and crop debris removed. The fields were ploughed and harrowed. They were then prepared to a fine tilth and levelled. Planting was done during the second week of March after the onset of long rains. The spacing was 45 cm by 20 cm for KAT Bean-9, 50 cm by 30 cm for cowpea M66 and 70 cm by 30 cm for lablab (Karanja *et al.*, 2006). Three seeds were placed in each planting hole and planted at a depth of 3-5 cm. First weeding was done at fourteen days after emergence. Thinning was done simultaneously with first weeding so as to achieve the required plant population. Second weeding was done five weeks after emergence (Karanja *et al.*, 2006). Duduthrin Super (Lambdacyhalothrin 50g/l) was sprayed to control African bollworm, legume pod borer and aphids at rates of 1 litre per hectare.

Data collection and analysis

Data was collected on biomass yield at physiological maturity and grain yield at harvest. Biomass samples were taken from all plots by cutting the plants at first node from the soil surface using secateurs and packed in a well labelled paper bag. Plant samples from each experimental unit were oven dried at 65°C for 48 hours and weighed. The three legumes were harvested from the net plot at physiological maturity. The pods were harvested, dried, threshed, winnowed and weighed. The dry weight of seeds harvested in the net plot was recorded and extrapolated to kilogram per hectare. Data were analysed using SAS statistical software version 9.3. Data collected were statistically evaluated by analysis of variance (ANOVA) using the general linear model; PROC GLM procedure (SAS, 2012). Least Significant Difference (LSD) test was used to separate treatment means significant at 95 % confidence level (Steel & Torrie, 1981).

RESULTS AND DISCUSSION

Biomass and grain yield of beans across the three locations

There were no significant differences ($P \leq 0.05$) observed in the KAT Bean-9 biomass yield across the three locations as shown in Table 1 below.

Table 1: Plant biomass yield of KAT Bean-9 across three locations in Makueni County

Location	Biomass yield at harvest (kg/ha)
Utafiti	651a
Machinery	773a
Mwanzo	695a
LSD	171
CV%	14

Means with different letters in the column are significantly different at $P \leq 0.05$.

There were no significant differences ($P \leq 0.05$) in the grain yield of bean KAT/B-9 across the three locations (Figure 2). The grain yield was highest in Mwanzo (533kg/ha) and lowest in Machinery (493 kg/ha). The mean grain yield of KAT Bean-9 across the three locations was 516 kg/ha.

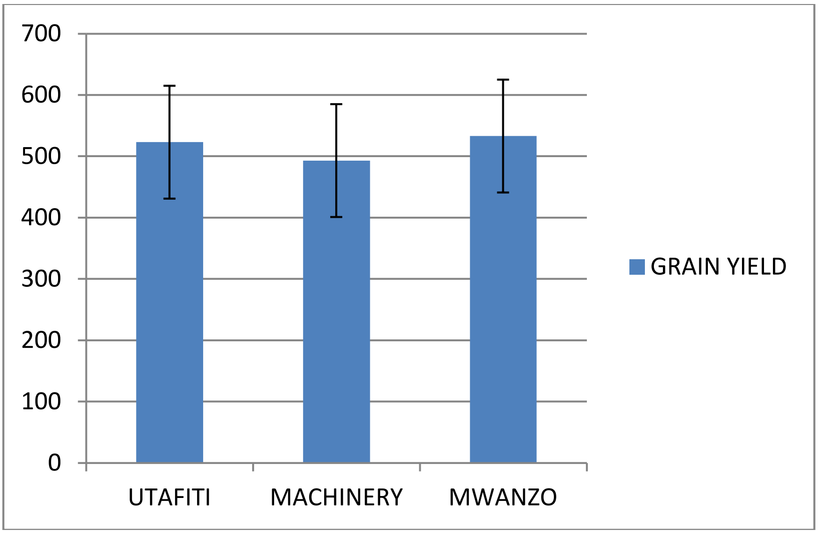

Figure 2: Grain yield of KAT Bean-9 (kg/ha) across three locations in Makueni County

There was no significant difference (P≤ 0.05) in the biomass and grain yield of KAT Bean-9 across the three locations. This could be attributed to the variety being early maturing hence escaping the effects of drought (Karanja *et al.*, 2006; Karugia *et al.*, 2012). However, the grain yields obtained were way below the potential yields of KAT Bean-9 as documented by Kenya Agriculture and Livestock Research Organisation (KALRO) and Kenya Plant Health Inspectorate Service (KEPHIS) which are estimated to be between 1400-1900 kg/ha (Karanja *et al.*, 2006; KEPHIS, 2014). This can be attributed to low soil fertility in the County (Kimiti, 2014).

Biomass and grain yield of cowpea across the three locations

Significant differences (P≤ 0.05) were observed in the biomass yield of cowpea at Machinery from the other locations (Table 2). Biomass yields in both Mwanzo and Utafiti were significantly higher than those of Machinery. However, there were no significant differences between their biomass yields.

Table 2: Plant biomass yield of cowpea M66 across three locations in Makueni County

Location	Biomass yield at harvest (kg/ha)
Utafiti	2840a
Machinery	1505b
Mwanzo	2770a
LSD	294
CV%	13

Means with different letters in the column are significantly different at *P≤ 0.05.*

There were significant differences observed (P≤ 0.05) in the grain yield of cowpea M66 across the three locations. The grain yields were highest in Mwanzo (1823 kg/ha) and lowest in Machinery (1282 kg/ha). The mean grain yield of cowpea M66 across the three locations was 1570 kg/ha.

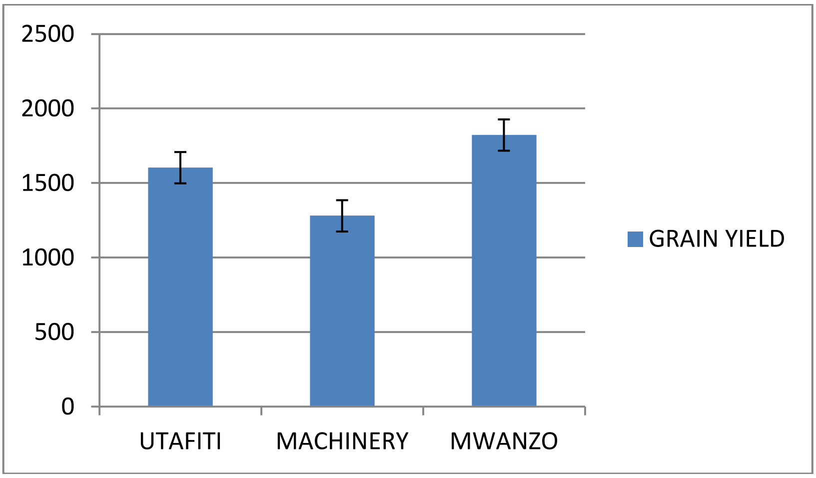

Figure 3: Grain yield of cowpea M66 (kg/ha) across three locations in Makueni County

The significant differences in biomass and grain yield of cowpea M66 in the three locations could be attributed to the effects of drought and moisture stress which were highest in Machinery and lowest in Mwanzo. Soil moisture enables plants absorb nutrients from the soil leading to better biomass and grain yields in legumes (Sun *et al.*, 2014). Moisture stress has been found to reduce the biomass and grain yields of cowpea (Suriyagoda *et al.*, 2010).

The actual grain yields obtained were at par with the potential yield of M66 variety documented by KALRO and KEPHIS which are between 1500 to 1800 kg/ha (Karanja *et al.*, 2006; KEPHIS, 2014). This can be attributed to the ability of cowpea to perform well under poor soil fertility conditions and greater P use efficiency (Alkama *et al.*, 2008).

Biomass and grain yield of lablab across the three locations

There were significant differences ($P \leq 0.05$) in the mean biomass yield of KAT/DL-1 across the three locations (Table 3). Biomass yields in both Mwanzo (4012 kg/ha) and Utafiti (3856 kg/ha) were significantly higher than those in Machinery (2767 kg/ha). However, there was no significant difference between their biomass yields. Significant differences ($P \leq 0.05$) were also observed in the biomass yield of CP1 81364 at Machinery (1813 kg/ha) from the other locations. Biomass yields in both Mwanzo and Utafiti were significantly higher than those of Machinery. However, there was no significant difference between their yields of 3092 kg/ha and 3179 kg/ha respectively. Overall, lablab variety KAT/DL-1 had a better biomass yield than accession CP1 81364.

Table 3: Plant biomass yield of lablab across three locations in Makueni County

Location	Lablab variety	Biomass yield at harvest (kg/ha)
Utafiti	KAT/DL-1	3856a
Utafiti	CP1 81364	3179b
Machinery	KAT/DL-1	2767c
Machinery	CP1 81364	1813d
Mwanzo	KAT/DL-1	4012a
Mwanzo	CP1 81364	3092b
LSD		207
CV%		11

Means with different letters in the column are significantly different at *P≤ 0.05*

There were significant differences (P≤ 0.05) observed in the mean grain yield of the two lablab varieties across the three locations. The grain yields of KAT/DL-1 at Machinery were significantly different (P≤ 0.05) from those of the other two locations. Machinery had a grain yield of 1282 kg/ha while Utafiti and Mwanzo had grain yields of 1604 kg/ha and 1823 kg/ha respectively. There were no significant differences between the grain yields of Utafiti and Mwanzo.

Significant differences (P≤ 0.05) were also observed in the grain yield of CP1 81364 at Machinery (881 kg/ha) as compared to the other two locations. However, the grain yields at Utafiti (1077 kg/ha) and Mwanzo (1193 kg/ha) were not significantly different. Overall, the mean grain yield of KAT/DL-1 was significantly higher than that of CP1 81364 in the three locations.

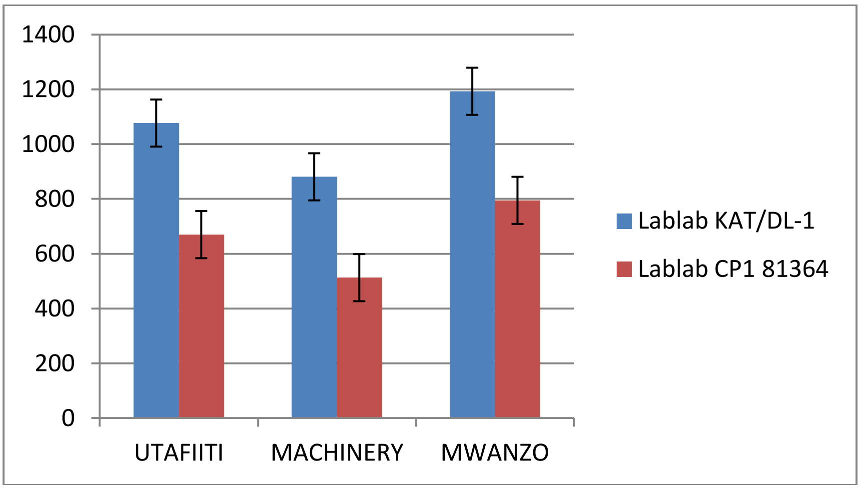

Figure 4: Grain yield of lablab (kg/ha) across three locations in Makueni County

The significantly higher biomass and grain yield of lablab at Utafiti and Mwanzo could be attributed to soil moisture deficit and low rainfall that was highest in Machinery

(Jaetzold *et al.,* 2010; Unpublished, 2014). Soil moisture deficit lowers mobility of nutrients especially phosphorous and nitrogen leading to decreased biomass and grain yields (Farooq *et al.,* 2009; Sun *et al.,* 2014). Studies have also shown that although lablab is drought tolerant, moisture stress during flowering and grain filling stages can greatly decrease the grain yields (Guretzki & Papenbrock, 2014).

CONCLUSION

From the results, it is concluded that KAT Bean-9 was equally suitable for the three agro-ecological zones. Cowpea variety M66 is more suited to LM4 agro-ecological zone while lablab variety KAT/DL-1 is suitable for LM4 and LM5 agro-ecological zones. Farmers could greatly improve yields if they cultivated legume varieties better adapted to their agro-ecological zones.

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