Yield Potential Of Different Certified Common Bean Varieties Under Different Tillage Methods In Kenya A Case Of Laikipia County

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ABSTRACT: Common bean (Phaseolus vulgaris L.) is the most important food legume for direct consumption with a higher per capita consumption in Africa estimated at 31.4 kg/year. Bean production is constrained by poor soil fertility, insufficient soil moisture, low yielding varieties and changes in weather. In order to improve yields, an integrated approach is required to address the limiting factors. The main objective of the study was to determine the yield potential of different common bean varieties under different tillage methods. Three tillage methods (zero, minimum and conventional tillage) and three bean varieties (Mwitenamia, KAT b9 and Mwezi moja) were tested in a randomized completed block design with three replicates. All yield parameters for the three bean varieties (number of grains per pod, weight of 100 gains, biomass above ground, weight per plot and harvest index) were significant (p < 0.05). KAT B9 and Mwezi moja were found to have higher yield potential and are recommended for production in Laikipia.

Keywords: Yield potential, Tillage methods, Beans Varieties, weather changes

1. INTRODUCTION

Laikipia County, like other parts in ASALs is predominantly characterised by low and variable rainfall, which rarely exceeds 750 mm. This amount is sufficient average rainfall to sustain crop growth if only it is well distributed over the crop life to obtain good yields. However, yields of most crops are known to be greatly reduced by periods of more than 10 consecutive dry days at critical growth stages of the crop which has become common with changing weather patterns in Laikipia. The high temperature (16 -26°C) experienced in the county increases evapotranspiration leading to high moisture losses further compromising the amount of water available for crop growth. There has been erratic weather patterns leading to frequent floods and droughts, (Laikipia County Integrated Development Plan [LCIDP], 2013) resulting in crop failure recorded in one out of every three seasons (Laikipia Wildlife Forum [LWF], 2013). Common beans require good tillage that ensures there is sufficient soil volume available to the roots to permits water percolation. The soil should also be well aerated. The production of common beans is constrained by among other things, tillage methods. In Laikipia County, the common practice in land preparation among small scale farmers is manual digging. This method does not prepare land appropriately or in time. The method is tedious, time consuming and does not go deep enough to break hardpans that may be present in the soil. There is limited information on alternative methods of land preparation for bean production in Laikipia County. Some of the methods like herbicide use are not friendly to the environment and are expensive to sustain. Others like minimum tillage are limited by the amount of area that can be prepared within a given period of time. It is for this reason that this experiment was designed to evaluate the effects of tillage methods on growth and yield of common bean and on correct choice of bean varieties suited to the climatic conditions of Laikipia. The bean crop is a vital food crop in the fight against food insecurity, malnutrition and poverty, (Katungi, Farrow, Mutuoki, Gebechewu, Karanja, … & Buruchara, 2010). It is primarily a small scale crop grown with few purchased inputs under poor agronomic practices subjected to biological, edaphic and climate problems. Because beans are a near “perfect” food, one of the best non-meat sources of iron and relatively inexpensive, its consumption is high for the poor masses and is a means of keeping malnutrition at bay. De Luque & Creamer (2014) notes that it is a source of protein, nutrition and income in SSA. It is on the basis of these facts that Food and Agriculture Organization of the United Nation [FAO] (1999) proposes that any advances in scientific research that benefit bean yields, particularly in developing countries, will contribute towards feeding the hungry and give hope for the future. In Laikipia, bean crop is listed as the second most important food crop in the fight against hunger after maize both for cash and consumption purposes (LCA, 2013). This report further notes that bean yields are generally low in most parts of the county compared to other parts of Kenya. Equally, the area under bean production in the county has dramatically reduced from 18,825 ha in 2012 to 1,659 ha in 2014. Yields have however improved over the same period from 7.6 bags (90 kg) ha⁻¹ to 9.8 bags ha⁻¹ indicating there is potential for increase (Ministry of Agriculture, Livestock and Fisheries [MoALF], 2015). Efforts to increase yields for common beans in Laikipia would therefore reverse the downward trend in its production and contribute to food security, better nutrition and increase in household incomes for small scale farmer. The dominant conventional tillage method widely practiced by farmers is known to reduce soil fertility through increased soil erosion, loss of soil organic matter and destruction of soil structure (Derpsch & Friedrich, 2009). Conservation
tillage on the other hand has been shown to improve soil fertility by building up soil organic matter, moisture and microbes (Gicheru, Gachene, Mbuvi, & Mare, 2004). This research presents an opportunity to demonstrate the benefits of adopting improved farming methods for common beans through implementation of alternative methods of land preparations and correct choice of bean varieties that lead to higher growth and yields in the county. The demand for food in the county is also expected to increase in view of a growing population of 14% over a five-year period from 2012 – 2017 (Republic of Kenya, 2012) making interventions geared toward improved yield a necessity if the County is to achieve and remain food secure. The research further contributes to improving farming technologies which have been said to limit productivity as outlined by the government in its assessment of the productivity of the key pillars in Kenya development plan as outlined in the country’s “Vision 2030”.

2. MATERIALS AND METHODS

2.1 Climatology and Soils
The experiment was carried out at two sites in Tigithi location in the semi-arid County of Laikipia, Kenya. The two sites are at an elevation of 2050 m above sea level. The area experiences a bimodal relief type of rainfall with the long rains occurring from March to May and the short rains occurring in October to November. The area receives an annual average rainfall of 400 – 750 mm with extended periods of dry spells. The soils are of the Vertisols type which are known to have an inherent fertility. Soils tests indicated a pH range of 5.8 – 6.9 which is favourably for production of beans. The experiment was established in the short rains of 2015.

2.2 Treatments and Plot Layout
There were two treatments, tillage methods (T) and bean varieties (V). Three different tillage methods; zero tillage (T1), minimum tillage (T2) and conventional tillage (T3) three common bean (Phaseolus vulgaris L.) varieties Mwitemania (V1), KAT B9 (V2) and Mwezi moja (V3) were tested. Each bean varieties was grown under the three different tillage methods.

<table>
<thead>
<tr>
<th>TILLAGE METHODS</th>
<th>BEAN VARIETIES</th>
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<tr>
<td></td>
<td>Mwitemania</td>
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<tr>
<td>Zero tillage</td>
<td>T1V1</td>
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<tr>
<td>Minimum tillage</td>
<td>T2V1</td>
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<tr>
<td>Conventional tillage</td>
<td>T3V1</td>
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The experiment was arranged in a Split block design on a randomized complete block design (RCBD) and replicated three times. The plots measured 3 m by 3 m with 1 m wide paths between plots and 2 m wide path between blocks.

2.3 Land preparation, fertilizer application and planting
The conventional till split blocks were prepared manually; firstly, by double digging to attain a depth of 30 cm and secondly using a forked manual tool - “jembe” to give a fine tilth of 30 cm deep. The minimum till split blocks were prepared manually using a mattock chisel with furrows reaching a depth of 30 cm followed by application of Glyphosate herbicide at a rate of 50 ml/20 litres. The zero till split blocks were subjected to application Glyphosate herbicide at the same rate to control weeds before planting. A basal application of nitrogen, phosphorus and potassium (N:P:K) was done at planting to give 38 kg ha\(^{-1}\) of N, 42 kg ha\(^{-1}\) of P and 55 kg ha\(^{-1}\) of K.

2.4 Data Collection
The research population comprised all the bean plants in all the treatments and correlated to the bean population in the replications. The representative units were selected by random sampling using transects in the experimental units to give the research sample. An equal number of subjects (5) were sampled in each treatment. During the growing period, quantitative data on yield parameters was collected and recorded. The measurements were taken at maturity. The parameters monitored were; Number of grains per pod at maturity, weight of 100 grain; total biomass (above ground) at maturity of a model plot measuring 1 m by 1 m from the centre of each plot, total yields per plot; and Harvest Index (HI). This weight together with the weight of the model plot for biomass above ground was used to calculate the HI using the formula below for each plot and the data recorded.

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HI = \frac{\text{Weight of grains in model plot (yield)}}{\text{Weight of total biomass above ground of model plot}}
\]

2.5 Data Analysis
All data was recorded and summarized in excel then analyzed using SPSS v 23. The data was presented both in words and visually using graphs and charts. Analysis of Variance (ANOVA) was conducted. A probability of 5% or less (p < 0.05) was used to differentiate varieties means according to the Least Significant Difference (LSD).
3. RESULTS AND DISCUSSIONS

3.1 The number of grains per pod
KAT B9 and Mwezi moja had higher number of grains per pod compared to Mwitemanina. The number of pods for Mwitemanina under minimum tillage also appeared more that the number of pods for the same variety under zero and conventional tillage methods. The results presented in figure 4.5.

3.2 The weight of 100 grains
It was observed that, the weight of 100 grains seemed to differ for all varieties with a more pronounced difference for Mwezi moja, followed by KAT B9 while Mwitemanina appeared to have the least weight.

3.3 Biomass above ground
The weight of the total biomass above ground for model plot measuring 1m by 1m showed variations in the weight of the different bean varieties.

ANOVA test confirmed there was significant difference (p < 0.05). The results of Post hoc test showed that the means of Mwitemanina and KAT B9 were significantly different (-7.767) as were the means of Mwitemanina and Mwezi moja (-12.94). The means of KAT B9 and Mwezi moja were also significantly different (-5.178). Mwezi moja had heavier grains compared to the other two varieties. The high weight of 100 grains for Mwezi moja could have resulted from the recorded high number of pods and which were also long allowing for more grains to set. Similar results were reported by (Mulugeta et al., 2013) showing that bean varieties with larger pods gave larger seeds leading to higher weight for a set number of grains. Msolla and Mduruma (2008) reported that the weight 100 seeds for a given variety was related to the period to maturity implying that early maturing varieties could have heavier seeds.
ANOVA recorded significantly different (p < 0.05) between varieties means. The means of Mwitemania and KAT B9 were significant (-83.38) as were the means of Mwitamania and Mwezi moja (-87.29). The total biomass above ground for KAT B9 and Mwezi moja were almost similar. These two varieties had more extensive and vigorous vegetative growth caused by a variation in genetic make-up giving them advantage over Mwitamania e.g. enabling the varieties to utilize soil moisture better at critical growth stages. These results agree with findings reported by Mduruma et al., (1998) who found that maturity and yield components of beans are influenced by the genetic variation.

3.4 Weight of per plot
The results of weight per plot indicated a much lower yield for Mwitamania compared to KAT B9 and Mwezi moja which showed almost similar yield results.

ANOVA test recorded significant difference (p < 0.05) between the varieties means. Post hoc test showed there were significant differences between the means of Mwitamania and KAT B9 (-508.81) as well as between the means of Mwitamania and Mwezi moja (-376.88). KAT B9 and Mwezi moja were almost similar. The high weight for Mwezi Moja and KAT B9 may have been influenced by their early maturity characteristics which may have given them an advantage over Mwitamania during the growing season. The results are supported by findings of Mduruma et al (1998) who reported that the superiority of early maturity in bean varieties results in higher yields in times of drought because such varieties are able to escape the drought due to genetic variation. Rao et al. (2013) also found that earliness or early maturity to be a useful trait for drought avoidance in common bean. The low yields for Mwitamania can separately be explained by the fact that the variety, which has been in existence since the 1970, Smithson (1990) and is low yielding has been over taken by genetic improvement in more recently developed varieties. The variety also has a small canopy area which may have caused higher evaporation rates in its plots leading to moisture stress for the crop. Earlier observations and data analysis for the growth and yield parameters seemed to indicate that Mwezi moja was set to be the better yielding variety. This variety was closely followed by KAT B9. This is because yield is a factor of both genetic, edaphic and environmental factors and their interaction. Male-Kayiwa (2000) agrees that edaphic factors do influence the productivity of the bean crop besides the genetic make-up as does Shenkalwa (2013) found that yield is a factor of both genotype and environmental factors.

3.5 Harvest index (HI)
KAT B9 appeared to have a higher HI followed by Mwezi moja while Mwitamania had the least HI.

ANOVA test confirmed that there was significant difference (p < 0.05) between the bean varieties means. There were significant differences between the means of Mwitamania and KAT B9 and between the means of Mwitamania and Mwezi moja. KAT B9 and Mwezi moja were almost similar. KAT B9 and Mwezi Moja recorded a higher HI than Mwitamania indicating they had higher yield potential in the area. The first two varieties competed favourably. KAT B9 has less canopy area compared to Mwezi moja which had recorded longer pods, more seeds per pod, higher weight for 100 grains and an almost equal total weight of biomass above ground to KAT B9 reducing the area available for evapotranspiration and therefore retaining more water than it was losing. The two varieties are also early maturing and could have escaped drought during the dry period over the growing cycle to record better performance. Similar results were documented by Mduruma et al (1998) and Rao et al. (2013) who found that early maturing varieties have the ability for drought avoidance in common bean. There is possibility that weather conditions at the time of conducting the research which were relatively dry may have favoured KAT B9 which is bred for drought tolerance compared to the other two varieties. Similar results were reported by Mitiri et al. (2013) who observed that yields of common beans tended to differ across seasons making it difficult to conclusively give credit to a particular variety as being better performing than others. Mwitamania which is preferred by most small scale farmers had a low HI and all along lagged behind in all the growth and yield parameters when compared to the other two varieties, indicating a need to improve the variety in order to incorporate better perfuming genotypes. This is supported by results of Shenkalwa et al. (2013) in their work.
when examining performance of improved bean varieties reported that improving the characteristics of old varieties improved their performance when compared to performance in the past.

4. CONCLUSION
The results showed that there were significant differences (p < 0.05) in the growth and yield parameters for all the bean varieties with the exception of number of day to flower onset namely; stem height, number of pods per plant, pod length, number of grains per pod, weight of 100 grain, total yields per plot, total biomass (above ground) and harvest index (HI). Mwezi moja recorded higher yields followed by KAT B9 while Mwitemia had the lowest yield. The two varieties were found to have higher yield potential and are recommended for production in the area. The research did not record any significant difference (p > 0.05) between the three different tillage methods. Similarly, there was no interaction recorded between tillage and bean varieties; similar bean varieties grown under different tillage methods recorded similar results for growth and yield parameters. This could be due to the fact that it takes more than one season for the benefits of conservation tillage to be realized. On the other hand, the fine tilth resulting from conventional tillage could have provided for vigorous crop growth leading to healthier crops with robust root and shoot systems that were able to utilize water and nutrients better thereby countering any marginal benefits that may have be caused by conservation tillage.

REFERENCES


Patricia has a B Sc. In Horticulture from Egerton University, Kenya and is currently pursuing a M Sc. In Agricultural and Rural Development from Kenya Methodist University. She is a programme manager at Zeitz foundation since 2013. She has worked with rural communities to implement agricultural and rural development projects across Kenya for over 12 years and she is a 2014 AWARD fellow.